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# Energy Subsidies and Environmental Sustainability in Afghanistan: Examining Global Warming Externalities

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**Abstract**

This study examines the trends and association between fossil fuel subsidies and global warming externalities in Afghanistan from 2015 to 2025. Methods of the Study: This study used a quantitative time-series design with 11 annual observations from the International Monetary Fund (IMF). The study used descriptive statistics, trend analysis, Pearson correlation, and Ordinary Least Squares (OLS) regression. We also conducted Augmented Dickey–Fuller tests and a stationary-transformation regression to assess the robustness of the findings. Fossil fuel subsidies fluctuated considerably, while global warming externalities generally increased. Pearson correlation indicated a significant positive association ($r = 0.6744$, $p = 0.0228$). The level OLS regression confirmed a significant positive relationship ($\beta = 0.9725$, $p = 0.023$). However, the stationary-transformation regression produced a positive but statistically insignificant association at the 5% level ($\beta = 0.2960$, $p = 0.089$). The findings suggest a positive association between fossil fuel subsidies and global warming externalities in the untransformed data. However, weaker evidence after accounting for non-stationarity limits the robustness of this relationship. Causal conclusions cannot be established. Policymakers should consider gradual subsidy reform, targeted energy assistance, and investment in cleaner energy sources, subject to further evaluation. Improved energy and environmental data collection and additional long-term research are recommended to support evidence-based policymaking.

**Keywords:** subsidies; externalities; warming; sustainability; energy; Afghanistan; emissions; taxation

# Subsidi Energi dan Keberlanjutan Lingkungan di Afganistan Menelaah Eksternalitas Pemanasan Global

**Abstrak**

Penelitian ini mengkaji tren dan hubungan antara subsidi bahan bakar fosil dan eksternalitas pemanasan global di Afganistan pada 2015–2025. Penelitian ini menggunakan desain kuantitatif deret waktu dengan 11 observasi tahunan dari Dana Moneter Internasional (IMF). Analisis meliputi statistik deskriptif, analisis tren, korelasi Pearson, dan regresi kuadrat terkecil biasa (OLS). Uji Augmented Dickey–Fuller dan regresi dengan transformasi stasioner juga dilakukan untuk menilai ketahanan temuan. Subsidi bahan bakar fosil berfluktuasi cukup besar, sedangkan eksternalitas pemanasan global secara umum meningkat. Korelasi Pearson menunjukkan hubungan positif yang signifikan ($r = 0{,}6744$; $p = 0{,}0228$). Regresi OLS pada data level menunjukkan hubungan positif yang signifikan ($\beta = 0{,}9725$; $p = 0{,}023$). Namun, regresi dengan transformasi stasioner menghasilkan hubungan positif yang tidak signifikan secara statistik pada taraf 5% ($\beta = 0{,}2960$; $p = 0{,}089$). Temuan menunjukkan hubungan positif antara subsidi bahan bakar fosil dan eksternalitas pemanasan global pada data yang belum ditransformasi. Namun, bukti yang lebih lemah setelah memperhitungkan ketidakstasioneran membatasi ketahanan hubungan tersebut. Kesimpulan kausal tidak dapat ditetapkan. Pembuat kebijakan perlu mempertimbangkan reformasi subsidi secara bertahap, bantuan energi yang tepat sasaran, dan investasi pada sumber energi yang lebih bersih, dengan tetap memerlukan evaluasi lebih lanjut. Peningkatan pengumpulan data energi dan lingkungan serta penelitian jangka panjang tambahan direkomendasikan untuk mendukung pembuatan kebijakan berbasis bukti.

**Kata kunci:** subsidi; eksternalitas; pemanasan; keberlanjutan; energi; Afganistan; emisi; perpajakan

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## INTRODUCTION

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Energy subsidies are an important policy instrument that supports energy affordability and economic activity. However, fossil fuel subsidies may also encourage greater consumption of carbon-intensive energy sources, raising concerns about environmental sustainability and global warming. In Afghanistan, where energy security, economic development, and environmental challenges remain significant concerns, understanding the relationship between energy subsidies and environmental externalities is particularly important. Despite growing international attention to fossil fuel subsidies and climate change, empirical evidence on this relationship in Afghanistan remains limited. Therefore, this study examines the association between fossil fuel subsidies and global warming externalities in Afghanistan from 2015 to 2025 using annual data from the International Monetary Fund (IMF). By analyzing trends and statistical relationships, the study aims to provide evidence that can inform discussions on energy policy, subsidy reform, and environmental sustainability, while recognizing that statistical associations do not establish causality.

A clear definition of subsidies is essential to this inquiry. The IMF distinguishes explicit subsidies, where users pay less than fuel supply costs, from implicit subsidies associated with underpricing environmental and other social costs (International Monetary Fund [IMF], n.d.). Global-warming externalities are monetary valuations of climate-related damages associated with fuel use, not measurements of temperature in Afghanistan. Consequently, a relationship between the two series concerns the selected economic indicators. It cannot, by itself, establish that a fiscal transfer caused a particular local warming outcome. Böhm and Peterson (2024) further distinguish subsidy inventories from net carbon-price measures, illustrating why definitions and measurement units matter for policy comparisons.

Recent empirical work provides both motivation and qualification. Arzaghi and Squalli (2023) examine fossil fuel subsidy policies and greenhouse gas emissions across countries, whereas Molendowski et al. (2023) investigate energy subsidies and emissions in the Visegrad Group and do not find an unambiguous relationship in their study period. Barak (2025) examines economic, environmental, and institutional determinants of subsidies using a dynamic panel framework. These approaches highlight the possibility of different directions of influence and common determinants. Afghanistan's short bivariate series can describe a local association, but cannot separate subsidy effects from changes in income, energy demand, fuel prices, governance, or other conditions that may affect both variables.

Reform also involves choosing among policy instruments. Van den Bergh et al. (2024) argue for prioritizing carbon pricing rather than treating subsidy removal as a sufficient climate strategy. Pereira and Pereira (2023) examine energy taxation reform in Portugal, while Hartono et al. (2023) analyze carbon taxation and revenue recycling in Indonesia. Argueyrolles et al. (2025) consider how gasoline and diesel subsidy reforms interact with biofuel mandates. Together, these studies locate subsidy reform within a wider policy mix. Their models and institutional settings differ from Afghanistan, so their results inform the questions considered here rather than providing transferable estimates of local fiscal, welfare, or emissions effects.

Distributional effects require particular attention. Vandeninden et al. (2022) assess whether fuel subsidies alleviate monetary and energy poverty in Burkina Faso, Rosas Flores et al. (2024) distinguish household welfare effects in Mexico, and Ginn (2024) considers the stabilization and welfare implications of subsidies in Malaysia. These studies show why expenditure totals alone do not identify who benefits or who bears the cost of reform. Gould et al. (2024) additionally argue that cooking-gas support can have health and equity benefits when the alternative is polluting biomass. Nazareth et al. (2024) emphasize equity in anti-fossil-fuel norms. The implication is to evaluate fuel uses, alternatives, and household vulnerability before recommending uniform withdrawal of support.

Political and administrative conditions also shape reform feasibility. Droste et al. (2024) examine renewable-energy market shares, institutional quality, and reform mechanisms in OECD countries; McAlexander et al. (2025) study political regimes and institutional capacity in gasoline pricing. Belgioioso and Newman (2025) connect subsidy reform with distributive justice and civil unrest. Yang and Moerenhout (2024) find that factual information alone does not necessarily change public support for gasoline subsidy reform in Nigeria. At the international level, Elliott et al. (2022) examine the credibility of reform references in climate commitments, and van Asselt (2023) considers the role of the Sustainable Development Goals. These perspectives caution against inferring implementation capacity or public acceptance from a statistically significant association.

Cleaner-energy investment should likewise be evaluated in its institutional context. Wong and Dewayanti (2024) discuss dependence on fossil fuels, subsidies, and renewables in Indonesia; Fitjriyah and Dwiputri (2025) examine green finance, trade openness, subsidies, and renewable-energy consumption across countries. Song et al. (2022) review renewable-energy subsidy arrangements in China, while Yahoo et al. (2024) analyze economic and environmental aspects of Malaysia's generation-mix targets. These contributions support considering investment, regulation, and financing alongside fossil fuel pricing. They do not establish which technologies, financing arrangements, or transition schedules would be feasible in Afghanistan, where such recommendations require additional country-specific evidence.

Data provenance is central to interpreting the present estimates. The IMF's 2025 update distinguishes historical estimates through 2024 from baseline projections beginning in 2025 (Black et al., 2025). The exact vintage and historical or projected status of the observations used in this study therefore need to be documented before all years can be interpreted as realized outcomes. Moreover, the global-warming valuation is constructed using fuel-consumption and damage-cost assumptions; changes can reflect those inputs rather than a directly observed climate event. This study consequently treats its results as exploratory associations between the reported series, with transparent recognition of measurement and sample limitations.

## Problem Statement

Fossil fuel subsidies may encourage fossil fuel consumption and increase environmental costs, including global warming externalities. However, empirical evidence on this relationship in Afghanistan remains limited. Therefore, this study examines the trends and association between fossil fuel subsidies and global warming externalities in Afghanistan from 2015 to 2025 using IMF data.

## Research Questions

- What are the trends in fossil fuel subsidies and global warming externalities in Afghanistan from 2015 to 2025?
- What is the relationship between fossil fuel subsidies and global warming externalities in Afghanistan from 2015 to 2025?
- To what extent are fossil fuel subsidies associated with global warming externalities in Afghanistan during 2015–2025?

## Research Objectives

To examine the trends in fossil fuel subsidies and global warming externalities in Afghanistan from 2015 to 2025.

To investigate the relationship between fossil fuel subsidies and global warming externalities in Afghanistan from 2015 to 2025.

To estimate the association between fossil fuel subsidies and global warming externalities in Afghanistan during 2015–2025.

### Hypothesis:

**$H_1$:** There is a significant positive association between fossil fuel subsidies and global warming externalities in Afghanistan.

**$H_0$:** There is no significant association between fossil fuel subsidies and global warming externalities in Afghanistan.

## LITERATURE REVIEW:

Coady et al. (2018) explain that energy price reform has become increasingly important because of climate change, air pollution, and financial pressures on governments. They discuss how fossil fuel prices should reflect not only the cost of producing and supplying energy but also the environmental damage caused by its use. The authors also highlight the economic and environmental benefits of changing energy prices. By reviewing experiences from different countries, the study identifies important lessons that policymakers can use when planning and implementing energy price reforms.

Rentschler and Bazilian (2017b) discuss the importance of reforming fossil fuel subsidies and their connection to climate change, government finances, and sustainable development. The authors explain that removing or reducing these subsidies can help governments improve their financial situation and support environmental goals. However, they also point out that subsidy reform can be difficult because of political, economic, and social factors, as well as changes in energy prices. Drawing on experiences from different countries, the study suggests carefully planning reforms to reduce negative social impacts while supporting long-term sustainable development.

As Davis (2017) explains, fuel subsidies for gasoline and diesel create costs in different countries. The study finds that these subsidies can create high external costs, including pollution, carbon emissions, traffic congestion, and road accidents. The study estimates total external costs at around $44 billion per year, plus about $26 billion in economic losses from inefficient resource use. Davis also argues that promoting alternative fuel vehicles alone may not solve these problems because such policies do not directly address issues such as traffic congestion and accidents. The study therefore shows that fuel subsidies can create wider economic and environmental costs for society.

According to Sinn (2008), reducing the demand for fossil fuels may not be enough to control climate change if the supply side is not also considered. When some countries reduce their fossil fuel use, global prices may fall, encouraging other countries to consume more. The author also suggests that fossil fuel producers may increase production and sell their reserves more quickly if they expect future demand and prices to decline. This could make efforts to reduce global warming less effective. Therefore, the study highlights the importance of considering both fossil fuel demand and supply when developing climate policies.

Drawing on Kverndokk (1994), the study examines how to manage fossil fuel extraction while accounting for the environmental damage caused by greenhouse gases. The study shows that the ideal carbon tax may rise at first but later fall, depending on how climate damage relates to atmospheric carbon levels. The author also explains that when future climate damages depend on changes in atmospheric carbon, different policies may be appropriate, including, in some situations, encouraging lower emissions through subsidies. When cleaner technologies are available, fossil fuels may still be used, but extraction should slow and be spread over a longer period. Overall, the study highlights the importance of considering both resource depletion and environmental impacts when managing fossil fuel use.

Fossil fuel prices may fail to reflect environmental and other social costs. The IMF framework distinguishes such implicit underpricing from explicit subsidies linked to supply costs (IMF, n.d.). This distinction is important because an estimate of environmental damages is not equivalent to a government budget transfer, and the two measures should not be interpreted interchangeably.

Kotchen (2021) examined how fossil fuel companies in the United States benefit from costs not included in fossil fuel prices. The research examined coal, natural gas, gasoline, and diesel, considering issues such as environmental pollution, health impacts, and transportation costs. The study estimated that fossil fuel producers receive about $62 billion in benefits each year because these costs are not fully included in fuel prices. The research also found that a large part of these benefits goes to a small number of companies. Overall, the study shows that fossil fuel producers can gain financially when the wider environmental and social costs of fossil fuels are not included in their prices.

Simanjuntak and Hartono (2024) examined the relationship between fuel subsidies and global warming costs in lower- and upper-middle-income countries. Using data from 2015 to 2022, the study examined whether fuel subsidy policies affect greenhouse gas emissions and climate-related costs. The results showed that fuel subsidies are associated with higher global warming costs in both groups of countries. The authors suggest that reducing fuel subsidies and improving policies to control carbon emissions could help reduce the negative effects of climate change. Overall, the study shows that fuel subsidy policies can have important environmental consequences in developing economies.

Kalmey et al. (2025) study the effects of removing fossil fuel subsidies and including the environmental costs of fossil fuel use in energy prices. Their research examines the economic and environmental effects of these policies across countries and sectors. The results suggest that pricing local environmental damages, especially air pollution, can improve economic welfare while also providing additional government revenue. The study also finds that this approach can reduce the carbon price needed to meet climate targets. However, simply removing direct fossil fuel subsidies has a smaller effect on welfare and emissions. Overall, the authors show that properly accounting for environmental costs in energy prices can support economic, government revenue, and climate objectives at the same time.

Kojima and Koplow (2015) explain why estimates of global fossil fuel subsidies vary widely. They note that different methods measure these subsidies, mainly the price-gap method and the inventory method. The price-gap method looks at the difference between the market price and the price consumers pay, while the inventory method identifies government policies that support fossil fuel production and consumption. The authors argue that both methods are useful because they provide different types of information about subsidies. They also note that differences in data and calculation methods can produce different estimates. The study recommends clearer definitions and consistent methods so countries can compare fossil fuel subsidies more easily. It also emphasizes that subsidy monitoring should be carried out regularly because governments need updated information to make informed policy decisions.

Ellis (2010) reviews the possible effects of removing fossil fuel subsidies and explains that governments need to consider economic, environmental, and social factors when making such changes. The study examines six major modeling studies that looked at the global effects of subsidy reform across different types of fossil fuels. Most focused on changes in greenhouse gas emissions and economic growth, while fewer considered other environmental and social effects. Ellis also identifies areas that need more research. Overall, the review shows that reducing fossil fuel subsidies can provide important economic and environmental benefits, while also highlighting the need for governments to carefully consider the wider effects of reform.

Koplow and Dernbach (2001) explain that fossil fuel support can affect production, consumption, and greenhouse gas emissions, and emphasize transparency in subsidy definition and

valuation. Their analysis supports making fiscal support and its environmental implications visible rather than treating all subsidy estimates as directly comparable.

Harring et al. (2023) examined how people in developing countries view the removal of fossil fuel subsidies and carbon taxes. The study explains that governments spend a large amount of money supporting fossil fuels, which can make it harder to reduce carbon emissions and use public money efficiently. The researchers collected data from five developing countries and compared public opinions on these policies. They found that removing fossil fuel subsidies was not necessarily viewed more negatively than introducing a carbon tax. The study also showed that people were more supportive when they knew how the government would use the money saved from reducing subsidies. This suggests that clearly explaining the benefits and how the saved money would be used may help people understand and accept subsidy reforms.

Victor (2009) studied why governments continue to provide large subsidies for fossil fuels even though they can create problems for government budgets, energy markets, and the environment. The study explains that removing these subsidies is often difficult because some powerful groups benefit from them and may oppose changes. Governments may use subsidies to support groups with strong political influence. Victor also points out that successful subsidy reform requires more than simply removing the subsidies. It may also require better government systems, broader policy changes, and support for groups that could lose benefits from the reform. Overall, the study shows that understanding the political and economic factors behind subsidies is important to successful reform.

Economic instruments provide several ways to address unpriced environmental costs. Carbon taxes and subsidy reform can influence incentives, but their effects depend on policy coverage, existing taxes, and the use of revenues. Recent analyses therefore assess subsidy removal alongside carbon pricing and revenue recycling rather than assuming a uniform response across economies (de Bruin & Yakut, 2023; Pereira & Pereira, 2023; van den Bergh et al., 2024).

de Bruin and Yakut (2023) examine how removing fossil fuel subsidies compares with using a carbon tax to reduce carbon emissions. The researchers use Ireland as a case study and look at the effects of removing several fossil fuel subsidies and increasing the carbon tax. Their findings show that both approaches can reduce emissions, but they affect the economy differently. The carbon tax has relatively smaller effects on economic growth and investment, while removing subsidies can increase government revenue and improve the country's financial position. However, subsidy removal may create greater difficulties for some industries and households. The study also explains that how the government uses the additional revenue can shape the overall economic effects. Therefore, the research shows that fossil fuel subsidy reform can be an important part of wider climate policies.

Rentschler and Bazilian (2017a) examine the problems that can result from fossil fuel subsidies and the difficulties involved in removing them. The authors explain that these subsidies can strain government budgets, increase fossil fuel use, and create social inequalities. However, past attempts to reform subsidies have yielded mixed results because governments often focus mainly on reducing immediate negative effects. Drawing on examples from different countries, the study explains that successful reform requires careful planning and policies that protect low-income and vulnerable groups. The authors also emphasize that governments should use the money saved from subsidy reform carefully to support long-term economic and sustainable development. In this way, subsidy reform can provide benefits beyond simply reducing government spending.

According to Tisdell (2019), the study examines why governments may provide financial support for solar and wind energy. The study considers both the environmental effects of different energy sources and whether these resources can be used sustainably in the long term. The author reviews previous

research and identifies limitations and areas needing further study. The research also uses economic ideas to explain how supporting renewable energy could improve social and economic well-being. Overall, the study broadens understanding of the choices between renewable energy and fossil fuels and explains the potential benefits of government support for clean energy development.

According to Skovgaard (2017), international organizations such as the IMF and OECD have approached fossil fuel subsidies differently. The study notes that the two organizations use different definitions to measure these subsidies. The IMF uses a broader definition that includes environmental costs, while the OECD takes a more traditional approach. The author explains that fossil fuel subsidies can be viewed from different perspectives, including government finances, the economy, environmental impacts, and effects on different groups in society. The study also shows that internal organizational processes and staff roles influenced how the IMF and OECD developed their different approaches. Overall, the research highlights the importance of using clear and consistent definitions when studying fossil fuel subsidies.

## RESEARCH METHODOLOGY:

This article used a quantitative time-series approach to examine the association between fossil fuel subsidies and global warming externalities in Afghanistan from 2015 to 2025. Secondary annual data were obtained from the International Monetary Fund (IMF), providing 11 observations for total explicit fossil fuel subsidies and global warming externalities. Data analysis was conducted using Stata. Descriptive statistics and trend analysis examined changes over time, while Pearson correlation and OLS regression assessed relationships among the variables. The Augmented Dickey–Fuller (ADF) test was used to study stationarity, followed by a stationary-transformation regression as a robustness check. Breusch–Godfrey, Breusch–Pagan/Cook–Weisberg, and Shapiro-Wilk tests were used for regression diagnostics. Statistical significance was primarily assessed at the 5% level. Given the small sample size and the data's time-series properties, the findings are interpreted as evidence of association rather than causation.

Explicit subsidies and the global-warming externality valuation are distinct IMF concepts (IMF, n.d.). The source vintage, series identifiers, extraction date, measurement units, and any projected years were not documented in the available study records. The reported 2015–2025 series and results are retained, but their source-level reproducibility cannot be established without that documentation. The 2025 IMF update provides a methodological reference rather than verification that this particular release generated the study data (Black et al., 2025).

## RESULTS

This section presents the empirical results of the study on the relationship between fossil fuel subsidies and global warming externalities in Afghanistan during 2015–2025. The analysis includes descriptive statistics, trend analysis, Pearson correlation, unit-root tests, regression analysis, robustness analysis, and diagnostic tests.

**Table 1.** Descriptive Statistics of the Study Variables, 2015–2025

| Variable | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Fossil Fuel Subsidies (FFS) | 11 | 0.1748 | 0.1122 | 0.0650 | 0.4002 |
| Global Warming Externality (GW) | 11 | 0.7012 | 0.1618 | 0.4235 | 0.9095 |

The descriptive statistics show that the total Fossil fuel subsidies in Afghanistan averaged 0.1748 during 2015–2025, with a standard deviation of 0.1122. The values ranged from 0.0650 to 0.4002, indicating considerable variation in fossil fuel subsidies over the study period. Global warming externalities recorded a mean value of 0.7012, with a standard deviation of 0.1618, ranging from 0.4235

to 0.9095. Overall, both variables exhibited variation during the study period, although fossil fuel subsidies showed greater relative variability around their mean.

The reported trend indicates that total explicit fossil fuel subsidies in Afghanistan fluctuated considerably between 2015 and 2025. Subsidies increased from approximately 0.065 in 2015 to 0.128 in 2019 before declining to 0.072 in 2020. A sharp increase occurred after 2020, reaching 0.307 in 2021 and peaking at 0.400 in 2022. Thereafter, subsidies declined to 0.260 in 2023, 0.246 in 2024, and 0.156 in 2025. Therefore, fossil fuel subsidies exhibited substantial year-to-year fluctuations rather than a consistent upward trend.

The reported global warming externalities exhibited a clearer long-term upward tendency. The value fell slightly from 0.466 in 2015 to 0.424 in 2016 but subsequently increased to 0.754 in 2019. Following a temporary decline to 0.678 in 2020, the externality increased to approximately 0.810 in 2021 and 2022. After a small decline in 2023, it increased again to 0.845 in 2024 and reached its highest reported value of 0.909 in 2025. Overall, the findings indicate a substantial increase in global warming externalities over the study period.

**Table 2.** Pearson Correlation Between Fossil Fuel Subsidies and Global Warming Externalities

| Variables | FFS | GW |
|---|---|---|
| Fossil Fuel Subsidies (FFS) | 1.000 | |
| Global Warming Externality (GW) | 0.6744 | 1.000 |
| p-value | 0.0228 | |
| N | 11 | 11 |

**Note:** Correlation is statistically significant at the 5% level.

The Pearson correlation analysis revealed a moderately strong positive and statistically significant relationship between fossil fuel subsidies and global warming externalities in Afghanistan during 2015–2025 ($r = 0.6744$, $p = 0.0228$). This indicates that years characterized by higher fossil fuel subsidies tended to coincide with higher global warming externalities. Since the p-value is below 0.05, the relationship is statistically significant at the 5% level. However, the correlation represents association and does not establish causality.

**Table 3.** Augmented Dickey–Fuller Unit Root Test

| Variable | Form | ADF Statistic | p-value | Result |
|---|---|---|---|---|
| FFS | Level | −1.615 | 0.4754 | Non-stationary |
| FFS | First difference | −2.554 | 0.1029 | Non-stationary |
| FFS | Second difference | −3.472 | 0.0087 | Stationary |
| GW | Level | −0.926 | 0.7792 | Non-stationary |
| GW | First difference | −3.458 | 0.0091 | Stationary |

Table 3 reports ADF tests that did not reject a unit root in either series at level. Under the reported specifications, rejection occurred after first differencing for GW and after second differencing for FFS. These results are conditional on the chosen deterministic terms and lag length, which require documentation. With only 11 annual data points, the tests have low power and the apparent integration orders should not be treated as firmly established. Failure to reject a unit root is not proof of non-stationarity, and rejection in a transformed series does not establish the adequacy of the subsequent regression.

## Ordinary Least Squares Regression

An ordinary least squares regression was initially estimated to assess the association between fossil fuel subsidies and global warming externalities.

Level model: $GW_t = \beta_0 + \beta_1 FFS_t + \varepsilon_t$
Estimated equation: $GW_t = 0.5312 + 0.9725 FFS_t$

**Table 4.** OLS Regression Results

| Variable | Coefficient | Std. Error | t-statistic | p-value | 95% Confidence Interval |
|---|---|---|---|---|---|
| Fossil Fuel Subsidies (FFS) | 0.9725 | 0.3549 | 2.74 | 0.023 | 0.1696–1.7754 |
| Constant | 0.5312 | 0.0728 | 7.30 | <0.001 | 0.3666–0.6958 |
| **Model Statistic** | | | | **Value** | |
| Number of Observations | | | | 11 | |
| R-squared | | | | 0.4548 | |
| Adjusted R-squared | | | | 0.3942 | |
| F-statistic | | | | 7.51 | |
| Prob > F | | | | 0.0228 | |

Table 4 shows that the coefficient of fossil fuel subsidies was positive and statistically significant at the 5% level (β = 0.9725, p = 0.023). This indicates that, in the level specification, a one-unit increase in fossil fuel subsidies was associated with approximately a 0.9725-unit increase in global warming externalities. The R-squared value of 0.4548 indicates that approximately 45.48% of the variation in global warming externalities was associated with variation in fossil fuel subsidies. However, because stationarity at level was not supported by the reported ADF results, the level regression should be interpreted cautiously and should not be considered a stable long-run relationship or evidence of causality.

## Stationary-Transformation Robustness Analysis

An additional regression relates the first difference of the global-warming externality series to the second difference of the explicit-subsidy series. This specification follows the reported ADF decisions, but estimates a relationship between different transformations rather than the same level association. Its slope therefore cannot be interpreted as a directly comparable estimate of the level effect.

Transformed model: $\Delta GW_t = \beta_0 + \beta_1 \Delta^2 FFS_t + \varepsilon_t$

**Table 5.** Stationary-Transformation Regression Results

| Variable | Coefficient | Std. Error | t-statistic | p-value | 95% Confidence Interval |
|---|---|---|---|---|---|
| $\Delta^2$ FFS | 0.2960 | 0.1499 | 1.97 | 0.089 | -0.0584–0.6505 |
| Constant | 0.0573 | 0.0216 | 2.65 | 0.033 | 0.0062–0.1083 |
| **Model Statistic** | | | | **Value** | |
| Number of Observations | | | | 9 | |
| R-squared | | | | 0.3578 | |
| Adjusted R-squared | | | | 0.2661 | |
| F-statistic | | | | 3.90 | |
| Prob > F | | | | 0.0888 | |

Table 5 shows that the coefficient of the second difference of fossil fuel subsidies remained positive at 0.2960. However, its p-value of 0.089 indicates that the association was not statistically significant at the conventional 5% level. The result is weakly significant only at the 10% level. The transformed specification does not reject a zero coefficient at 5%. Because the two models use different transformations and sample sizes, the smaller coefficient is not evidence that a single causal effect has diminished.

Note. The transformed model uses nine observations. Its dependent variable is ΔGW and its predictor is $\Delta^2$FFS. Statistical inference remains exploratory because the small sample, uncertain

integration classification, and undocumented data provenance limit the interpretation of the nominal p-values.

## Regression Diagnostic Tests

Diagnostic tests were reported for the level OLS model. Their interpretation is limited by the small sample, and failure to reject a diagnostic null hypothesis does not establish that the model is correctly specified.

**Table 6.** Regression Diagnostic Test Results

| Diagnostic Test | Statistic | p-value | Conclusion |
|---|---|---|---|
| Breusch–Godfrey LM Test | $\chi^2 = 3.672$ | 0.0553 | No significant first-order autocorrelation at 5% |
| Breusch–Pagan/Cook–Weisberg Test | $\chi^2 = 0.49$ | 0.4820 | Homoskedasticity not rejected at 5% |
| Shapiro–Wilk Test | $W = 0.9680$ | 0.8652 | Normality not rejected at 5% |

The Breusch–Godfrey LM test produced a p-value of 0.0553, indicating that the null hypothesis of no first-order serial correlation could not be rejected at the 5% significance level. However, the result was close to the conventional significance threshold and should be interpreted cautiously.

The Breusch–Pagan/Cook–Weisberg test did not reject homoskedasticity ($p = 0.4820$), and the Shapiro–Wilk test did not reject residual normality ($p = 0.8652$). These are non-rejections in a very small sample; they do not prove constant variance or normality, establish stationarity, or validate causal inference. Diagnostics for the transformed model were not reported.

## Hypothesis Testing

The study proposed the following hypotheses:

**$H_1$:** There is a significant positive association between fossil fuel subsidies and global warming externalities in Afghanistan.

**$H_0$:** There is no significant association between fossil fuel subsidies and global warming externalities in Afghanistan.

The Pearson correlation analysis showed a statistically significant positive association between fossil fuel subsidies and global warming externalities ($r = 0.6744$, $p = 0.0228$). Similarly, the level OLS regression produced a positive and statistically significant coefficient for fossil fuel subsidies ($\beta = 0.9725$, $p = 0.023$).

The nominal correlation and level OLS tests reject a zero-association null at 5%. However, inference from these level tests is conditional on assumptions that are not securely established for this small time-series sample. They do not provide an unqualified rejection of the null across model specifications.

However, the stationary-transformation regression produced a positive but statistically insignificant coefficient at the 5% level ($\beta = 0.2960$, $p = 0.089$). Therefore, although the findings provide evidence of a positive association, the relationship is not robustly significant in the transformed specification.

## DISCUSSION:

The findings indicate a positive association between fossil fuel subsidies and global warming externalities in Afghanistan during 2015–2025. The trend analysis showed that fossil fuel subsidies fluctuated considerably, while global warming externalities generally increased over the study period. Pearson correlation confirmed a moderately strong and significant positive relationship ($r = 0.6744$, $p = 0.0228$),

while the level OLS regression also showed a significant positive association (β = 0.9725, p = 0.023). These findings are broadly consistent with the economic and environmental literature suggesting that fossil fuel subsidies can encourage fossil fuel consumption by lowering energy costs and thereby contribute to greenhouse gas emissions and climate-related externalities. In this respect, the reported association is compatible with the general argument that maintaining fossil fuel subsidies may conflict with environmental and climate objectives. However, the robustness analysis provides a more cautious conclusion. After accounting for non-stationarity, the relationship remained positive but was not statistically significant at the 5% level (β = 0.2960, p = 0.089). Thus, while the level analysis supports the hypothesis of a significant positive association, the transformed model provides only weaker evidence. This difference highlights sensitivity to specification. Since the transformed regression concerns changes rather than levels, neither the coefficient sizes nor their p-values establish a causal mechanism. Comparable emissions research also reports context-dependent patterns (Arzaghi & Squalli, 2023; Molendowski et al., 2023).

The findings are further limited by incomplete documentation of the data units, release vintage, and estimate or projection status. The global-warming measure is an economic valuation, so its movement should not be interpreted as observed changes in Afghanistan's temperature. Common measurement inputs, changes in fuel consumption, and omitted economic factors may contribute to the association. These limitations should be resolved before using the reported coefficients to quantify policy effects.

## CONCLUSION:

The study examined the association between fossil fuel subsidies and global warming externalities in Afghanistan from 2015 to 2025. The results showed that fossil fuel subsidies fluctuated considerably over the study period, while global warming externalities generally followed an upward trend. Pearson correlation analysis indicated a statistically significant positive relationship between the two variables (r = 0.6744, p = 0.0228). The level OLS regression also indicated a positive and significant association (β = 0.9725, p = 0.023), explaining approximately 45.48% of the variation in global warming externalities. However, after accounting for non-stationarity, the relationship remained positive but was not statistically significant at the 5% level (β = 0.2960, p = 0.089). Therefore, the findings suggest that fossil fuel subsidies are positively associated with global warming externalities in Afghanistan, but the association is sensitive to specification and does not establish a causal relationship. The results should be interpreted cautiously because of the small sample size and the time-series properties of the data.

## RECOMMENDATION:

Gradual Reform of Fossil Fuel Subsidies: The Afghan authorities should consider gradually reviewing and reforming fossil fuel subsidies, particularly those that may encourage inefficient fossil fuel consumption. Any reform should consider energy affordability and the needs of vulnerable households.

Promote Cleaner Energy Sources**:** Greater attention should be given to renewable and cleaner energy sources, particularly solar, wind, and other locally appropriate alternatives, to reduce dependence on fossil fuels and their associated environmental externalities.

Targeted Energy Support**:** Instead of broad fossil fuel subsidies, support could be better targeted toward low-income households and essential sectors. This may help protect vulnerable groups while reducing incentives for excessive fossil fuel consumption.

Integrate Environmental Considerations into Energy Policy**:** Policymakers should consider the environmental costs associated with fossil fuel use when designing energy and subsidy policies. Energy affordability, economic development, and environmental sustainability should be addressed together.

Improve Energy and Environmental Data: Relevant institutions should strengthen the collection and reporting of consistent data on fossil fuel subsidies, fuel consumption, greenhouse gas emissions, renewable energy, and environmental externalities. Better data would support more reliable policy analysis.

Further Research: Future studies should use longer time periods and include additional variables such as GDP, fossil fuel consumption, carbon emissions, population growth, energy intensity, and renewable energy use. More comprehensive econometric models could help determine whether the observed association represents a causal relationship.

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## Conflicts of Interest

A declaration of competing interests was not specified in the available study documentation.

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