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RESEARCH ARTICLE

Estimating Annual per Capita Mineral and Hydrocarbon Consumption in Ecuador Using U.S. Data as a Baseline

Christian Adrián OrdóñezGuaycha[1]*, Josué David González Coronel[2], Julio Cesar López Ayala[3], Ernesto Reyes Cespedes[4]

[1,2,3,4]Escuela Superior Politécnica de Chimborazo (ESPOCH), Sede Morona Santiago, Macas EC140101, Ecuador

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***Corresponding Author:**

cordoniez@espoch.edu.ec

ABSTRACT

In 2008, Ecuador became the first country to legally recognize the rights of nature, a significant step in environmental protection. This principle has been reinforced through referenda opposing resource extraction, particularly oil and mining. Despite these environmental concerns, the contribution of the extractive industry to Ecuador's economy is substantial, representing 4.4% of the national GDP and 41.73% of foreign investment in 2020. This study estimates the annual per capita consumption of minerals and hydrocarbons in Ecuador, providing an objective view of the population's reliance on these resources. Using U.S. per capita mineral consumption data from 2023 as a baseline, this study employs proportional scaling based on Ecuador's employment rate and GDP per capita. Results show that, in 2023, an average Ecuadorian consumed approximately 2,993.1 kg of minerals and metals and 2,766.55 kg of hydrocarbons. These findings highlight the essential role of these resources in Ecuador's economy and daily life, contributing valuable data for discussions on sustainable resource management.

INTRODUCTION

In 2008, Ecuador became the first country to officially recognize the rights of nature (*15 años de los Derechos de la Naturaleza en Ecuador - GARN Latinoamérica*, 2023; *Base legal para DDN en Ecuador - Observatorio Jurídico de Derechos de la Naturaleza*, 2019; *Derechos de la Naturaleza en Ecuador*, 2018), reflecting the country's deep commitment to environmental protection. This commitment has been reaffirmed through a series of popular referenda, in which Ecuadorians have consistently voted against the extraction of natural resources such as crude oil and minerals (AFP, 1 C.E.; Press, 2023). Many of these referenda have been supported by politicians, which has helped them gain popularity. These campaigns, often aimed at opposing oil and mining projects, have persuaded people that such activities indiscriminately pollute the environment, leading to biased voting outcomes.

However, there has been little to no campaigning in support of the extractive sector, highlighting its benefits. For example, the mining industry has become crucial to Ecuador's economy (Torres, 2020). Projects like Lundin Gold and ECSA have significantly contributed to the country's development,

accounting for 4.40% of the national GDP. In 2020, the mining sector represented 41.73% of foreign investment (*EN 2020, LA MINERÍA DEJÓ RESULTADOS ECONÓMICOS POSITIVOS PARA EL ECUADOR – Ministerio de Energia y Minas*, n.d.). Additionally, there is little emphasis on how everyday products, derived from minerals and oil, are essential to modern life, making it difficult to imagine our lives without them.

The present research aims to estimate the annual per capita consumption of minerals and hydrocarbons by Ecuadorians, providing an objective perspective on the population's reliance on these resources. The study does not advocate for any specific mining or crude oil company but rather emphasizes Ecuadorians' dependence on minerals and crude oil. Quantifying the precise consumption of these resources per individual is a challenging task due to the complexity of supply chains and the diverse applications of these materials. To tackle this, a methodological approach was used, where data from the United States' per capita mineral consumption in 2023 served as a baseline for estimating Ecuador's consumption. Two key economic indicators—employment rate and GDP per capita—were employed to scale the U.S. data to the Ecuadorian context. The findings suggest that, on average, an Ecuadorian in 2023 consumed approximately 2,993.1 kg of minerals and metals, and 2,766.55 kg of hydrocarbons.

MATERIALS AND METHODS

As global societies advance and technologies evolve, the demand for a variety of mineral commodities has significantly increased (Morgan, 1976; Qadri et al., 2024). However, precise annual mineral and hydrocarbons consumption per individual remains a critical, yet under-examined, statistic. This study follows a structured, three-step methodological approach to estimate individual mineral and hydrocarbons consumption, with a comparative focus on the United States and Ecuador.

Step 1: Selection of Relevant Studies on Mineral and Hydrocarbons Consumption

To address the diverse array of minerals in existence (Rao, 2022; Al-Khresheh., 2024), we first select the minerals most relevant to daily life. Using the Google search engine, keywords such as "mineral consumption" and "minerals human needs" were used to identify studies on daily mineral requirements. The publication "How many pounds of minerals are required by the average person in a year?" by the Minerals Education Coalition and cited by the United States Geological Survey (*How Many Pounds of Minerals Are Required by the Average Person in a Year? | U.S. Geological Survey*, n.d.; *USGS Open-File Report 01-360: Mineral Resources; out of the Ground...into Our Daily Lives*, n.d.) was chosen as the primary guide, listing critical minerals relevant to individual consumption. Table 1 displays the selected minerals and hydrocarbons, which serve as the baseline for scaling Ecuadorian mineral and hydrocarbons consumption.

Step 2: Data Proportion Factors and Estimation

Given the absence of direct studies on per capita mineral and hydrocarbons consumption in Ecuador, this study uses proportional factors to estimate these values. The key indicators analyzed include employment rate and Gross Domestic Product (GDP) per capita.

Employment Rate: Employment rate, an essential economic indicator, is known to influence consumption patterns within a country. Numerous studies demonstrate the complex, interdependent relationship between employment levels and consumption trends (Adekoya & Faraz, 2021; Clements et al., 2020; Jam et al., 2016; Xu et al., 2021; Yoo, 2005).

GDP per Capita: GDP per capita is frequently used as a proxy for living standards and the general level of consumption in a country (Ha et al., 2020; Kakkad & Ray, 2022; Al-Khresheh., 2023).

Due to the complexity of gathering demand elasticity data for each mineral in Ecuador, only employment rate and GDP per capita from the USA and Ecuador, spanning from 2018 to 2023, were

selected as proportion factors for this estimation. The proportional calculation involves dividing the average employment rate of Ecuador by that of the USA and similarly for GDP per capita, as outlined in Tables 2 and 3. Each proportion factor is then multiplied by U.S. mineral and hydrocarbons consumption data to derive an estimated consumption rate for Ecuadorians in 2023.

RESULTS

Step 1: U.S. Minerals and Fuel Consumption 2023

The baseline mineral and fuel consumption per capita for the USA in 2023, as shown in Table 1, forms the foundation for estimating Ecuadorian mineral consumption.

Table 1: Estimated annual consumption of various minerals and fuels per person in the USA (2023)

Material	Amount (SI Units)	Material	Amount (SI Units)
Stone	4,783 kg	Zinc	2.72 kg
Sand and gravel	3,105 kg	Soda ash	12.25 kg
Cement	358 kg	Manganese	2.27 kg
Iron ore	107.5 kg	Other non-metals	302 kg
Salt	164 kg	Other metals	9.07 kg
Phosphate rock	71.7 kg	Silver	18.14 g
Clays	68.5 kg	Petroleum	4,175 liters
Aluminum	5.44 kg	Coal	1,155 kg
Lithium	9.07 g	Natural gas	2,724 m^3
Copper	5.44 kg	Uranium	54.43 g
Lead	4.99 kg		

Source: ("Mining & Mineral Usage Statistics," n.d.)

Step 2: Calculation of Proportion Factors

The average U.S. employment rate from 2018 to 2023 was 59.67%, while Ecuador's was 35.77%, as shown in Tables 2. This results in Ecuador's employment rate being 59.95% of that of the USA. Similarly, the average U.S. GDP per capita was $70,510.67, compared to Ecuador's $6,169.33, making Ecuador's GDP per capita 8.75% of that of the USA.

These proportions were applied to the U.S. mineral and hydrocarbons consumption data to estimate Ecuadorian consumption, with results shown in Tables 4 and 5.

Tables and Data Sources

Table 2: Employment Rate Data

Year	USA Employment Rate (%)	Ecuador Employment Rate (%)
2023	60.8	35.9
2022	59.9	33.2
2021	58.6	34
2020	56.8	32.5

2019	61.2	37.9
2018	60.7	41.1
Average	59.67	35.77

Sources: (*Annual Employment Rate U.S. 2023*, n.d.; *United States Employment Rate*, n.d.) (*Empleo-Ene-2021 |*, n.d.; *Tres de Cada 10 Trabajadores Tienen Un Empleo Adecuado En Ecuador*, 2022; *Tasa de empleo adecuado en Ecuador subió 2,6% entre 2017 y 2018*, n.d.; *El 2023 Cerró Con Más Desempleo En Ecuador*, n.d.)

Table 3: GDP per Capita Data

Year	USA GDP per Capita (USD)	Ecuador GDP per Capita (USD)
2023	81,695	6,533
2022	77,247	6,477
2021	71,056	6,036
2020	64,317	5,450
2019	65,548	6,204
2018	63,201	6,316
Average	70,510.67	6,169.33

Sources: (*U.S. GDP Per Capita 1960-2024*, n.d.) (*Ecuador GDP Per Capita 1960-2024*, n.d.).

Estimation Results

The estimated annual mineral and hydrocarbons consumption per capita in Ecuador for 2023 is presented in Tables 4–5, based on different proportion factors (employment rate and GDP per capita).

According of the average of these tables, each person uses approximately 1,642.96 kg of stone and 1,066.57 kg of sand and gravel, which are essential materials in construction and infrastructure (de Morais et al., 2013; Novelo et al., 2021; Oladinrin et al., 2012). Cement consumption reaches 122.97 kg per person, while iron ore amounts to 36.93 kg and salt 56.33 kg, all crucial for industrial and domestic applications. Phosphate rock and clays contribute 24.62 kg and 23.53 kg respectively to agricultural (Hellal et al., 2019; Ihbach et al., 2020)and industrial uses while . Among trace minerals, zinc reaches 0.94 kg, manganese 0.78 kg, and other metals 3.12 kg. Precious minerals like silver are consumed at 6.23 grams per capita, and lithium at 3.12 grams, reflecting their significance in electronics and battery production (Xiao et al., 2020). Petroleum and coal, key energy sources (Bellussi et al., 2014), are consumed at 1,434.11 liters and 396.74 kg per person, respectively, with natural gas consumption at 935.7 m^3. Finally, uranium consumption, at 18.7 grams per capita, supports energy needs (Bellussi et al., 2014). This diverse mineral profile underscores the broad range of mineral resources essential to Ecuador's economy and daily life.

Table 4: Estimated Annual Mineral and Hydrocarbons Consumption in Ecuador (Employment Rate Proportion)

Material	Amount (SI Units)	Material	Amount (SI Units)
Stone	2,867.41 kg	Zinc	1.63 kg
Sand and gravel	1,861.45 kg	Soda ash	7.34 kg
Cement	214.62 kg	Manganese	1.36 kg
Iron ore	64.45 kg	Other non-metals	181.05 kg

Material	Amount (SI Units)	Material	Amount (SI Units)
Salt	98.32 kg	Other metals	5.44 kg
Phosphate rock	42.98 kg	Silver	10.87 g
Clays	41.07 kg	Petroleum	2502.91 liters
Aluminum	3.26 kg	Coal	692.42 kg
Lithium	5.44 g	Natural gas	1,633.04 m^3
Copper	3.26 kg	Uranium	32.63 g
Lead	2.99 kg		

Table 5: Estimated Annual Mineral and Hydrocarbons Consumption in Ecuador (GDP Proportion)

Material	Amount (SI Units)	Material	Amount (SI Units)
Stone	418.51 kg	Zinc	0.24 kg
Sand and gravel	271.69 kg	Soda ash	1.07 kg
Cement	31.32 kg	Manganese	0.2 kg
Iron ore	9.41 kg	Other non-metals	26.42 kg
Salt	14.35 kg	Other metals	0.79 kg
Phosphate rock	6.27 kg	Silver	1.59 g
Clays	5.99 kg	Petroleum	365.31 liters
Aluminum	0.48 kg	Coal	101.06 kg
Lithium	0.79 g	Natural gas	238.35 m^3
Copper	0.48 kg	Uranium	4.76 g
Lead	0.44 kg		

DISCUSSION

There is no research about the consume per capita of mineral and hydrocarbons in Ecuador, but also it is difficult to find one around the world. Most of the investigation claims that the global demand for mineral commodities has been steadily increasing due to population growth, urbanization, and technological advancements. (Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply, 2017; Pomykała & Tora, 2017) Owing to the continuing increase in global population and the efforts to improve living standards worldwide, the use of mineral resources will persist to grow in the foreseeable future (Schulz & Briskey, 2003).

In this research, the estimated per capita consumption for Ecuador was derived using data from a previous study conducted in the United States. The results highlight the annual demand for key resources in Ecuador: approximately 2,945.72 kg of minerals, 47.38 kg of metals, and 2,766.55 kg of hydrocarbons. To estimate these figures, employment rate and GDP per capita were used as proportional conversion factors, as these indicators reflect broader consumption patterns within a population.

AUTHORS' CONTRIBUTIONS

Christian Ordóñez led the research, conducted the analysis, and wrote the initial draft of the article. Josue Gonzalez, Julio López, and Ernesto Reyes contributed to reviewing the manuscript and provided critical feedback, making adjustments to improve the overall quality and clarity of the work. All authors have read and approved the final version of the manuscript.

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