Amazon River Water Transfer as a Solution to Drought and Food Insecurity in Northeastern Brazil

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Abstract

This paper evaluates the technical, energetic, economic, and environmental feasibility of diverting a fraction of the Amazon River discharge at its mouth for large-scale irrigation of Brazil's semi-arid Northeast. By quantifying water demand, agricultural productivity, pumping energy requirements, infrastructure costs, and potential economic returns, the study argues that a controlled transfer—powered primarily by nuclear energy—could transform the semi-arid region into a major agricultural hub while maintaining negligible impact on the Amazon basin. Updated literature and data are incorporated to contextualize desalination benchmarks, irrigation efficiency, energy costs, and environmental implications.

Keywords: Amazon River, water transfer, semi-arid Northeast, irrigation, nuclear energy, food security, climate adaptation.

1. Introduction

Brazil simultaneously hosts one of the largest freshwater surpluses on Earth and one of the most persistent semi-arid regions. The Amazon River alone discharges approximately 216,000 m^3/s into the Atlantic Ocean, while recurrent droughts in Northeastern Brazil impose chronic agricultural, social, and economic losses. This asymmetry motivates the examination of inter-basin water transfer as a strategic adaptation to climate variability and food insecurity.

Previous proposals for large-scale water redistribution in Brazil—most notably the São Francisco River transposition—have faced political resistance due to competition among existing users. In contrast, capturing a limited fraction of Amazon River discharge at its mouth would not deprive upstream ecosystems or populations, as this water is otherwise lost to salinization in the Atlantic. Similar large-scale hydraulic projects exist worldwide (e.g., China's South–North Water Transfer Project), demonstrating that the concept is technically feasible under appropriate governance and environmental safeguards.

2. Economic Value of Freshwater and the Cost of Waste

The economic value of freshwater can be benchmarked using desalination costs. Global experience indicates that large-scale desalination plants typically produce freshwater at costs between US$0.50 and US$2.00 per cubic meter, depending on technology and energy prices (Elimelech & Phillip, 2011; Ghaffour et al., 2013).

At an average discharge of 216,000 m^3/s, the Amazon River releases roughly 18.7 billion m^3 of freshwater per day into the ocean. Valued conservatively at US$0.50/$m^3$, this corresponds to a notional economic value of approximately US$9 billion per day. While this does not imply that all such water should be captured, it highlights the scale of the resource relative to regional scarcity elsewhere in Brazil.

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3. Water Demand in the Semi-Arid Northeast

The semi-arid region of Northeastern Brazil covers approximately 1.2 million km^2. Empirical studies of irrigated agriculture in comparable climatic conditions (e.g., the Paracatu River basin) indicate an average irrigation demand of about 0.35 $L\ s^{-1}\ ha^{-1}$, rising to 0.50 $L\ s^{-1}\ ha^{-1}$ during peak evapotranspiration periods.

Adopting the conservative average value and converting units yields a demand of approximately 0.035 $m^3\ s^{-1}\ km^{-2}$. For the entire semi-arid region, this corresponds to a total irrigation requirement of roughly 42,000 m^3/s ($\approx 1.3 \times 10^{12}$ m^3/year). This demand vastly exceeds the discharge of the São Francisco River, underscoring the inadequacy of local river systems for region-wide irrigation.

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4. Agricultural Production Potential

Assuming diversified cultivation of high-storage grains—rice, maize, and soybean—under irrigated conditions, typical yields are approximately:

- Rice: ~7.0 t/ha
- Maize: ~4.8 t/ha
- Soybean: ~2.8 t/ha

If the semi-arid area were evenly divided among these crops and supported by irrigation, total annual production (assuming up to three harvests per year) could reach approximately 1.7 billion tonnes of grain. Using conservative international prices, the gross annual value of this production would be on the order of US$700–750 billion.

Net profit margins in mechanized agriculture typically range from 30% to 40% of gross output. Even adopting the lower bound, the potential annual net profit could exceed US$250–300 billion, placing the project among the largest agricultural transformations ever contemplated.

5. Energy Requirements for Water Pumping

The primary energetic cost of the project is lifting water from sea level at the Amazon mouth to an average elevation of approximately 300 m in the semi-arid interior. The hydraulic power required is given by:

$$P = \rho g Q h$$

where ρ is water density, g gravitational acceleration, Q flow rate, and h elevation.

For a flow of 42,000 m³/s and an elevation of 300 m, the required power is approximately 126 GW. Kinetic energy contributions associated with flow velocity are negligible by comparison.

Nuclear energy is considered due to its high power density, low operational carbon emissions, and cost competitiveness for baseload generation. Current estimates place nuclear generation costs between US$0.015 and US$0.025 per kWh in mature programs (OECD/NEA, 2020).

At US$0.017/kWh, the annual energy cost of continuous operation would be approximately US$19 billion—less than 10% of the estimated annual net agricultural profit.

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6. Infrastructure Costs

6.1 Nuclear Power Plants

Assuming a capital cost of US$2,000 per kW of installed nuclear capacity, providing 126 GW would require an investment of approximately US$250 billion. This capacity could be distributed across multiple reactors to enhance redundancy and grid stability.

6.2 Water Conveyance Infrastructure

Large-diameter concrete pipelines operating at moderate flow velocities (~1 m/s) would be required. Order-of-magnitude estimates suggest total pipeline and installation costs on the order of US$2 billion—small relative to energy infrastructure costs.

6.3 Labor and Phased Deployment

Labor costs, benchmarked against mega-projects such as Itaipu, are modest relative to total capital expenditure. Importantly, the project could be implemented incrementally: initial stages would irrigate limited areas, generate revenue, and finance subsequent expansion.

7. Environmental Considerations

Diverting approximately 20% of the Amazon River's discharge at its mouth would not measurably affect upstream ecosystems or navigation. Nuclear-powered pumping avoids greenhouse gas emissions associated with fossil fuels. In the receiving region, expanded vegetation cover would likely reduce surface temperatures, enhance local humidity, and potentially increase regional precipitation through land–atmosphere feedbacks.

Nevertheless, detailed environmental impact assessments would be mandatory, particularly regarding coastal dynamics near the river mouth, salinity gradients, and biodiversity responses in newly irrigated areas.

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8. Conclusion

This analysis suggests that a controlled transfer of a fraction of Amazon River discharge to Northeastern Brazil is technically feasible and economically transformative. Even under conservative assumptions, the project's annual net benefits could exceed its total capital cost within a few years of full operation. Beyond economic returns, the proposal addresses food security, climate adaptation, and regional inequality. While political, institutional, and environmental challenges are non-trivial, they are not commensurate with the scale of the potential benefits.

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