EPRA International Journal of Economic Growth and Environmental Issues- Peer Reviewed Journal
ISSN: 2321-6247
Volume: 12 | Issue: 10 | November 2024 | Journal DOI: 10.36713/epra0713 | SJIF Impact Factor (2024): 8.619

INDIAN BIOFUEL POLICY FUTURES: ENERGY AND LAND FORECASTS

Dilna K S, Aaron George
International Centre for Technological Innovations (ICTI), Alappuzha, Kerala

----------ABSTRACT----------
The pursuit of sustainable energy sources has positioned biofuels as a viable alternative to fossil fuels, particularly in the context of India's growing energy demands and environmental concerns. Utilizing historical data from the World Bank, this study forecasts changes in India's agricultural land (% of land area) and renewable energy consumption (% of total final energy consumption) up to 2030 through Exponential Smoothing (ETS) in R. The projections indicate a decline in agricultural land and a rise in renewable energy consumption. Yet the question remains: How can India reconcile the decreasing availability of agricultural land with the ambitious targets set in its National Biofuel Policy? Through SWOT, PESTEL, and GAP analyses of India's National Biofuel Policy (2018) and its 2022 amendment, this study identifies strategic opportunities and challenges. The findings suggest that leveraging advanced biofuel technologies, optimizing land use, and implementing targeted policy actions are crucial for aligning biofuel production with sustainability goals. The study emphasizes the importance of sustainable land management, technological innovation, and stakeholder engagement to enhance the biofuel sector's contribution to India's energy security and environmental objectives.

KEYWORDS: *National Biofuel Policy, forecasting, ETS, agricultural land, renewable energy consumption, India.*----------

1. INTRODUCTION

Biofuels have emerged as a promising alternative to fossil fuels, offering the potential to reduce greenhouse gas emissions and enhance energy security (Usmani et al., 2023). India, with its growing population and energy needs, faces the challenge of expanding renewable energy sources while managing limited land resources. Historical trends show shifts in agricultural land use and renewable energy consumption, but the interplay between these factors remains complex. Yet the question remains: How can India achieve its biofuel production targets amid declining agricultural land availability?

This study aims to address this critical question by forecasting agricultural land use and renewable energy consumption up to 2030 and analyzing the implications for India's biofuel policy. By employing Exponential Smoothing (ETS) forecasting and conducting comprehensive policy analyses, the study seeks to provide insights into optimizing biofuel strategies in the context of land resource constraints.

2. METHODOLOGY

Data Sources

The study utilizes historical data from the World Bank's Data Bank for India:

- **Agricultural land (% of land area):** Data from 1961 to 2021.
- **Renewable energy consumption (% of total final energy consumption):** Data from 1990 to 2021.

Forecasting Method

The Exponential Smoothing (ETS) method was employed to forecast agricultural land use and renewable energy consumption up to 2030. ETS is a time series forecasting technique suitable for data with trends and seasonality, applying weighted averages where the weights decrease exponentially over time (Hyndman and Athanasopoulos, 2018).

Data Analysis Tools

Data analysis and forecasting were conducted using R, a statistical computing software. The 'forecast' package in R was utilized to implement the ETS model (Hyndman et al., 2023).

EPRA International Journal of Economic Growth and Environmental Issues- Peer Reviewed Journal
ISSN: 2321-6247
Volume: 12 | Issue: 10 | November 2024 | Journal DOI: 10.36713/epra0713 | SJIF Impact Factor (2024): 8.619

3. RESULTS

Forecast of Agricultural Land Use and Renewable Energy Consumption

The ETS forecasts indicate a continued decline in agricultural land as a percentage of total land area and an upward trend in renewable energy consumption.

Table 1: Forecasted Values for Renewable Energy Consumption and Agricultural Land

Year	Renewable Energy Consumption (% of total final energy consumption)	Agricultural Land (% of land area)
2024	36.1	60.0041
2025	36.4	59.9880
2026	36.7	59.9735
2027	37.1	59.9602
2028	37.4	59.9481
2029	37.7	59.9372
2030	38.0	59.9272

These projections underscore the challenge of increasing biofuel production without exacerbating land scarcity issues.

Analysis of India's National Biofuel Policy (2018) and 2022 Amendment

SWOT Analysis

Strengths • **Ambitious Targets:** Setting high blending targets (20% ethanol by 2025-26) demonstrates commitment (Ministry of Petroleum and Natural Gas, 2022). • **Diversified Feedstock:** Inclusion of various feedstocks reduces dependency on food crops (Usmani et al., 2023). • **Advanced Biofuels Emphasis:** Focus on 2G and 3G biofuels utilizing waste and non-food biomass. • **Indigenous Production:** Aligns with 'Make in India' to boost domestic industries.	**Weaknesses** • **Infrastructure Limitations:** Insufficient blending and distribution infrastructure (Government of India, 2022). • **Technological Gaps:** Need for advancements in biofuel technologies (Ministry of Petroleum and Natural Gas, 2018). • **Feedstock Supply Variability:** Agricultural variability affects consistent feedstock availability. • **Regulatory Hurdles:** Complex approval processes hinder rapid implementation.
Opportunities • **Waste-to-Energy Potential:** Utilizing municipal waste can alleviate land pressure (Asian Development Bank, 2008). • **Algal Biofuels:** High-yield feedstocks like algae require less land (Ministry of Economy, Trade and Industry, 2018). • **Rural Development:** Biofuel industry can create employment and boost rural economies. • **International Collaboration:** Opportunities for technology transfer and partnerships.	**Threats** • **Declining Agricultural Land:** Limits expansion of traditional biofuel crops (World Bank, n.d.). • **Climate Change Impact:** Affects crop yields and feedstock production. • **Competing Renewables:** Solar and wind energy advancements may overshadow biofuels. **Environmental Concerns:** Risk of biodiversity loss due to land use changes.

PESTEL Analysis

Political	Strong governmental support but requires inter-ministerial coordination.
Economic	Potential for reducing oil imports but requires significant investment.
Social	Public awareness and acceptance need enhancement; potential impact on food security.
Technological	Necessity for R&D in advanced biofuels; technology adoption challenges.
Environmental	Potential for GHG reduction; concerns over land degradation and water use.
Legal	Regulatory frameworks need updating; compliance with international standards.

EPRA International Journal of Economic Growth and Environmental Issues- Peer Reviewed Journal
ISSN: 2321-6247
Volume: 12 | Issue: 10 | November 2024 | Journal DOI: 10.36713/epra0713 | SJIF Impact Factor (2024): 8.619

GAP Analysis

Current State	Desired State
• Ethanol blending at approximately 8.1% (Ministry of Petroleum and Natural Gas, 2022). • Reliance on first-generation biofuels. • Limited infrastructure and technological capabilities.	• Achieve 20% ethanol blending by 2025-26. • Adoption of advanced biofuel technologies. • Sustainable and efficient feedstock supply chains. • Enhanced infrastructure and skilled workforce.
Gaps Identified	
• **Technological Development:** Need for innovation in biofuel production methods. • **Infrastructure Expansion:** Upgrading blending facilities and distribution networks. • **Policy Implementation:** Streamlining regulations and fostering investment. • **Education and Training:** Developing expertise in biofuel technologies and practices.	

4. DISCUSSION

The declining trend in agricultural land poses a significant challenge to India's biofuel ambitions. With land resources shrinking, relying on traditional biofuel crops may not be sustainable (Ministry of Petroleum and Natural Gas, 2018). The forecasted increase in renewable energy consumption reflects the nation's commitment to diversifying its energy portfolio (Government of India, 2022).

To reconcile these opposing trends, India must pivot towards feedstocks that do not compete with food production and require less land, such as agricultural residues, municipal waste, and algae (Usmani et al., 2023). Embracing advanced biofuel technologies will be crucial in this transition.

Moreover, addressing infrastructural and technological gaps is imperative. Investment in R&D, fostering public-private partnerships, and enhancing policy frameworks can drive innovation and efficiency in the biofuel sector. The question of balancing biofuel production with land availability is complex. However, by leveraging technological advancements and strategic policy measures, India can work towards achieving its biofuel targets without compromising food security or environmental sustainability.

5. CONCLUSION

The study highlights the critical intersection of declining agricultural land and increasing renewable energy needs in India. To address the central question of how to achieve biofuel targets amid land constraints, the following recommendations are proposed:

- **Feedstock Diversification:** Prioritize non-land-intensive feedstocks like algae and waste materials.
- **Technological Innovation:** Invest in R&D for advanced biofuel technologies and support their commercialization.
- **Infrastructure Development:** Upgrade blending facilities and establish efficient distribution networks.
- **Policy Enhancement:** Simplify regulatory processes and provide clear guidelines to encourage investment.
- **Capacity Building:** Implement training programs to develop a skilled workforce in the biofuel industry.
- **Sustainability Focus:** Enforce environmental regulations to ensure sustainable biofuel production practices.
- **Stakeholder Engagement:** Foster collaboration among government, industry, academia, and the public.

By adopting these strategies, India can navigate the challenges posed by land scarcity and capitalize on the opportunities within the biofuel sector to enhance energy security and achieve environmental objectives.

6.REFERENCES

1. *Asian Development Bank (ADB). (2008). Biofuels in Asia: An Analysis of Sustainability Options. ADB.*
2. *Government of India. (2022). Energy Statistics India 2022. Ministry of Statistics and Programme Implementation.*
3. *Hyndman, R. J., & Athanasopoulos, G. (2018). Forecasting: Principles and Practice (2nd ed.). OTexts.*
4. *Hyndman, R. J., Athanasopoulos, G., & Zhou, Z. (2023). forecast: Forecasting functions for time series and linear models. R package version 8.16.*

5. *Ministry of Economy, Trade and Industry (METI). (2018). Fifth Strategic Energy Plan. Government of Japan.*
6. *Ministry of Petroleum and Natural Gas. (2018). National Policy on Biofuels - 2018. Government of India.*
7. *Ministry of Petroleum and Natural Gas. (2022). National Policy on Biofuels - 2018 Amendment. Government of India.*
8. *Usmani, R. A., Mohammad, A. S., & Ansari, S. S. (2023). Comprehensive biofuel policy analysis framework: A novel approach evaluating the policy influences. Renewable and Sustainable Energy Reviews, 183, 113403.*
9. *World Bank. (n.d.). World Development Indicators. Retrieved October 15, 2024, from https://databank.worldbank.org*

Appendix

Availability of Code and Data

The R code, input files, and output files used for the analyses in this paper are available at the following GitHub repository: https://github.com/ajgnelli/biofuel