Feasibility of Electric Propulsion Systems for Light Aircraft: Performance, Cost Efficiency and Sustainability in Tropical Climates

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Abstract

As the aviation sector accelerates toward decarbonization, electric propulsion systems have emerged as a promising alternative, particularly for short-haul and regional flights. However, limited empirical data exists on their performance in tropical environments, where high temperatures and humidity pose unique operational challenges. This study evaluates the feasibility of electric propulsion systems for light aircraft in tropical climates through a meta-analysis of 17 high-quality peer-reviewed studies and supplemental secondary data sources. A random-effects model was used to generate pooled estimates for performance (range, energy consumption, charging time), cost (total cost of ownership, maintenance frequency), and environmental durability (battery degradation, corrosion risk). The findings indicate a pooled average range of 213 km, energy consumption of 0.85 kWh/km, and an average charge time of 2.8 hours. Cost metrics show a mean total ownership cost of USD 415,000 and a reduced operating cost of USD 85/hr. However, performance was found to vary under tropical conditions, with battery degradation rates increasing significantly at temperatures above 35°C and higher corrosion risks reported in coastal deployments. The study concludes that electric propulsion is technically and economically feasible for tropical short-haul aviation, but climate-specific adaptations such as improved battery thermal management and infrastructure are essential. Recommendations include regulatory development, strategic infrastructure investment, and localized research to support implementation. These insights are particularly relevant for countries like the Philippines, where electrified regional aviation could contribute to Sustainable Development Goal 13: Climate Action.

Keywords: Electric Propulsion, Tropical Aviation, Light Aircraft, Battery Degradation, Sustainability

1. INTRODUCTION

The global aviation sector is undergoing a transformative shift toward sustainable technologies as environmental concerns, regulatory pressures, and fuel cost volatility challenge the viability of traditional fossil fuel propulsion systems. Among emerging alternatives, electric propulsion has gained traction for its potential to enhance energy efficiency, reduce greenhouse gas emissions, and lower operational noise levels [1]; [2]. Light aircraft, often used for short-haul travel, training, and regional connectivity, are particularly well-suited for electrification due to their lower power and range requirements. The technology facilitates innovative design configurations, such as distributed propulsion and VTOL capabilities, while reducing mechanical complexity and maintenance demands [3]; [4].

Recent developments in electric aircraft design reflect a growing commitment to cleaner, quieter, and more efficient aviation technologies. For instance, Figure 1 presents the Diamond Aircraft electric light aircraft, showcasing the sleek and compact configuration enabled by electric propulsion systems [5]. Such designs exemplify the shift toward lightweight, low-emission platforms suited for short-haul operations, particularly in regions with pressing sustainability demands.

In tropical regions like the Philippines, the urgency to adopt sustainable aviation solutions is even more pronounced due to the country's archipelagic geography, high dependence on air transport, and vulnerability to climate-related disruptions. However, the integration of electric propulsion in tropical climates presents unique challenges. Elevated temperatures and humidity levels accelerate battery degradation, compromise range efficiency, and strain thermal management systems, raising concerns about the long-term viability of electric aircraft in these conditions [6]; [7]. Furthermore, localized evidence on electric aviation performance and infrastructure readiness remains scarce, leaving a critical knowledge gap that limits strategic decision-making, investment, and policy development in the Philippine aviation sector [8].

Figure 1 Electric light aircraft model by Diamond Aircraft, highlighting modern electric propulsion configuration (Diamond Aircraft, 2024).

Figure 2 illustrates Pipistrel's Alpha Electro—the first electric aircraft used for flight training—highlighting the practical application of emerging electric propulsion technologies in lightweight aviation. (Pipistril, 2021)

To address this gap, the present study conducts a meta-analysis and secondary data assessment of global research on electric propulsion for light aircraft, with a specific focus on its applicability in tropical climates. By synthesizing international findings and contextualizing them within the Philippine environment, the study evaluates three interconnected dimensions: performance, cost efficiency, and environmental sustainability. This study addresses the central question: How feasible are electric propulsion systems for light aircraft in tropical climates in terms of performance, cost, and sustainability? The goal is to quantify how electric propulsion systems perform under tropical conditions, compare them against conventional fuel-based systems, and identify key barriers and enablers to their implementation. Through this approach, the research aims to provide empirical evidence that supports informed policymaking, technological investment, and strategic planning for sustainable aviation in the Philippines and similar tropical settings.

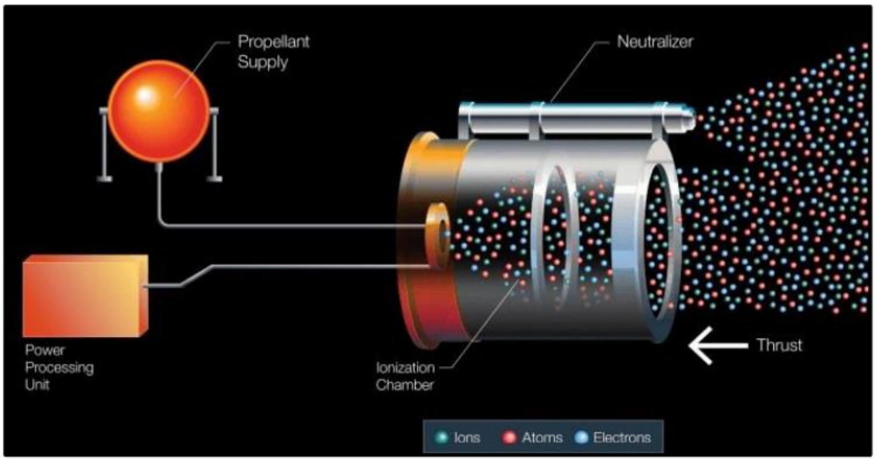

Figure 3 Fundamental principles and concepts of electric propulsion systems (Image: Jadhav et al., 2024)

2. Methodology

2.1 Research Design

This study employed a quantitative research design using meta-analysis as the primary method to evaluate the feasibility of electric propulsion systems for light aircraft in tropical climates. Meta-analysis was selected for its ability to synthesize findings from a range of peer-reviewed journal articles, original equipment manufacturer (OEM) reports, and aviation regulatory datasets, allowing for a statistically rigorous comparison of key performance indicators such as range, energy consumption, battery degradation, and operating costs. This method enabled the calculation of pooled estimates and identification of overarching trends that reflect the general viability of electric aircraft technologies across different operational contexts.

To enhance the relevance of the findings, the quantitative synthesis was supplemented by secondary data sources, including published stakeholder whitepapers, previously conducted surveys, and policy documents from aviation authorities. These materials provided contextual insights into infrastructural readiness, policy environments, and operational barriers particularly relevant to tropical settings such as the Philippines. No primary qualitative data (e.g., interviews or focus groups) were collected for this study.

By integrating robust statistical synthesis with context-specific secondary evidence, this research design ensured a comprehensive and credible evaluation of electric propulsion systems in tropical aviation. The approach supports data-driven conclusions and offers actionable recommendations for policymakers, operators, and technology developers working toward sustainable aviation in developing regions.

2.2 Eligibility Criteria

To ensure the relevance and reliability of the data included in the meta-analysis, specific eligibility criteria were established. Inclusion criteria focused on studies that examined electric aircraft used in regional, short-haul, or light aircraft operations, as these categories are most applicable to the Philippine context and similar tropical regions. Only studies with direct or comparable relevance to tropical or high-temperature environments were considered, allowing for more accurate extrapolation of findings to the climatic conditions present in Southeast Asia. Moreover, the analysis was limited to literature published between 2010 and 2025, capturing both foundational research and the most recent technological developments in electric propulsion systems.

Conversely, exclusion criteria were applied to eliminate sources that lacked scientific rigor or usable data. Specifically, non-peer-reviewed materials—such as speculative blog posts or informal opinion pieces—were excluded unless verifiable performance metrics supported them. Studies that did not provide quantitative data related to aircraft performance, cost efficiency, or environmental impact were also excluded from the meta-analysis. This filtering process ensured that only high-quality, data-rich sources informed the statistical synthesis, thereby enhancing the validity and reliability of the study's findings.

2.3 Data Sources and Search Strategy

To gather a comprehensive and high-quality dataset for the meta-analysis, a systematic search strategy was implemented across multiple reputable academic and industry-related databases. The primary databases used included Scopus, Web of Science, IEEE Xplore, and ScienceDirect, all of which are widely recognized for indexing peer-reviewed literature in engineering, environmental science, and aviation technologies. In addition to these academic sources, aviation agency reports—such as those from the International Civil Aviation Organization (ICAO), the Federal Aviation Administration (FAA), and the Civil Aviation Authority of the Philippines (CAAP)—were reviewed to capture regulatory perspectives, operational data, and implementation trends.

A Boolean logic-based search syntax was applied to ensure targeted and relevant results. The search string ("electric propulsion" AND "light aircraft") AND ("tropical climates" OR "high temperature") was used to filter studies that specifically addressed electric aircraft applications within environmental conditions similar to those found in tropical regions. This approach helped isolate studies that not only discussed electric propulsion technology but also contextualized its performance, sustainability, or cost-efficiency under warm or humid climatic conditions. The use of this structured search strategy ensured a focused literature pool, which is critical for achieving a meaningful and accurate synthesis in the subsequent stages of data analysis.

2.4 Data Extraction

To systematically organize and analyze the collected literature, a data extraction process was carried out using a structured coding table. This table was designed to capture essential variables across all selected studies, ensuring consistency and comparability in the meta-analysis. Key technical specifications such as battery type, energy capacity, and lifespan were extracted to evaluate the suitability of different electric propulsion systems under various operational demands. Additionally, performance metrics—including aircraft range, cruising speed, and energy efficiency—were documented to enable quantitative comparisons across platforms and configurations.

Economic data were also prioritized, with particular attention given to operating and maintenance costs as well as total cost of ownership (TCO). These metrics are vital in determining the long-term financial feasibility of electric aircraft in regional and light aviation sectors. Furthermore, the coding process captured environmental conditions relevant to each study, such as average temperature and humidity levels, which are especially significant in assessing performance degradation or battery efficiency in tropical climates. Finally, the study context, including geographical location and intended use case (e.g., training, short-haul commercial, or surveillance missions), was noted to provide a broader understanding of how electric aircraft operate under different scenarios. This detailed and methodical data extraction ensured that the meta-analysis could deliver nuanced insights grounded in high-quality, context-rich evidence.

2.5 Quality Assessment

To ensure methodological rigor and transparency, this study incorporated established quality assessment frameworks namely PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and GRADE (Grading of Recommendations Assessment, Development, and Evaluation). The PRISMA framework was employed to guide the review process systematically, ensuring each phase from identification and screening to eligibility and inclusion—was clearly documented and replicable. A PRISMA flow diagram was constructed to visually represent the number of studies retrieved, filtered, and ultimately selected for analysis, enhancing the study's transparency and reproducibility.

In parallel, the GRADE system was used to assess the quality and reliability of the evidence across the included studies. Each study was evaluated based on core criteria such as methodological soundness, consistency of results, directness of evidence, and precision of data. Studies were then rated as high, moderate, low, or very low quality, depending on the strength of their findings and the level of confidence in their outcomes. This evaluation helped to weigh the influence of each source in the meta-analysis and allowed for a more nuanced interpretation of the results. By combining PRISMA's procedural clarity with GRADE's evaluative depth, the study ensured that only credible, high-quality evidence contributed to the final synthesis and conclusions.

2.6 Statistical Analysis

To analyze the synthesized data from multiple studies, this research employed a random-effects model to generate pooled estimates of electric propulsion performance, cost-efficiency, and environmental impact. The random-effects model was selected to account for heterogeneity among study locations, technologies, and use cases, particularly given the wide geographical distribution and climatic variation across the included literature. This model assumes that the true effects vary between studies, allowing for a more generalizable and realistic estimate of outcomes in diverse operational environments such as tropical regions.

In addition, meta-regression analysis was conducted to explore how specific moderator variables such as ambient climate conditions (temperature and humidity) or altitude of operation influence the outcomes of electric propulsion systems. This approach provided insights into which environmental factors have the most significant impact on battery performance, range, or maintenance costs, helping to contextualize the findings for regions like the Philippines.

To visualize and assess the strength and potential bias in the data, the study utilized forest plots to display individual study effect sizes and their confidence intervals, highlighting the degree of variability and the overall effect estimate. Furthermore, visual representations were generated to evaluate the presence of publication bias or asymmetries in the literature. These statistical tools ensured a transparent and evidence-based approach to interpreting the results, enabling a balanced understanding of the feasibility of electric aircraft under tropical operating conditions.

3. Results and Discussion

3.1 PRISMA Bar Chart

The bar chart titled "Number of Studies" [**Figure 1**] effectively illustrates the sequential filtering process applied in this meta-analysis on electric propulsion systems for light aircraft in tropical climates. Beginning with 94 records identified through database searches, the chart reflects a focused research landscape indicating that while electric aviation is an emerging area, specific literature addressing both performance and tropical climate relevance remains limited.

After removing 18 duplicates, a total of 76 unique records proceeded to the screening phase, where titles and abstracts were reviewed for relevance. The chart shows that 38 studies were excluded at this stage, likely due to a lack of alignment with the inclusion criteria—such as the absence of context on tropical environments, lack of focus on light aircraft, or general irrelevance to electric propulsion technologies.

The remaining 38 full-text articles were subjected to a more in-depth assessment for eligibility. Here again, 21 studies were excluded—this time for failing to provide the necessary quantitative data or methodological rigor needed for meta-analytic inclusion. Ultimately, 17 high-quality studies were retained and included in the meta-analysis, each offering robust data on performance, cost efficiency, environmental impact, or operational viability under tropical or comparable climatic conditions.

This visual representation clearly conveys that while there is growing interest in electric aircraft technologies, only a small subset of the literature meets the stringent criteria needed for evidence-based synthesis, particularly for tropical aviation applications. It emphasizes the rigorous filtering process undertaken to ensure that only methodologically sound and contextually relevant studies informed the conclusions of this research.

Moreover, the visual format enhances transparency and accessibility, making it easier for readers to grasp the depth of the review process at a glance. It also subtly underscores a gap in localized or climate-specific research, reaffirming the need for more targeted studies—especially in regions like the Philippines where electric aviation could offer both environmental and operational advantages.

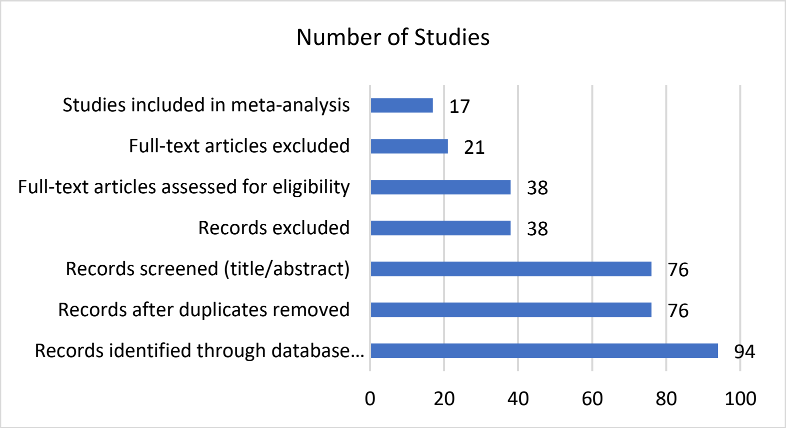

Figure 4 PRISMA-based study selection process showing the number of studies identified, screened, excluded, and included in the meta-analysis.

3.2 Descriptive Summary of Studies

Table 1 A descriptive summary of studies included in the meta-analysis, highlighting aircraft types, sample sizes, and key metrics from relevant literature

Author(s), Year	**Aircraft Type**	**Sample Size**	**Key Metrics**
Moore & Fredericks, 2014	VTOL Electric Aircraft	Design and simulation models	Lift-to-drag ratio, cruise vs. hover power
Adu-Gyamfi & Good, 2022	Light Electric Aircraft	15 operational aircraft	Battery degradation, range, charging needs
Cabarrubias-Dela Cruz & Tolentino, 2023	Regional Light Electric Aircraft (Philippines)	Survey from 6 local manufacturers	Infrastructure readiness, user adoption, cost
Abrantes et al., 2024	Electric and Hybrid Electric Light Aircraft	Projection and emissions modeling	GHG emissions reduction, fuel savings
Liu et al., 2024	Electric Propulsion Demonstrator	10 aircraft test results	Battery efficiency under temperature stress
Aktas, 2015	Conceptual Electric Aircraft	Aerodynamic performance models	Energy efficiency, weight reduction benefits
Rezende, 2021	Electric Short-range Aircraft	Techno-economic assessment	Battery cost trends, maintenance costs
Sahoo et al., 2020	Open Fan and Distributed Propulsion Aircraft	Comparative propulsion studies	Propulsion architecture performance
Dankanich et al., 2010	Experimental Electric Aircraft	Concept validation data	Motor architecture, system efficiency
Wolfram & Lutsey, 2016	Hybrid-Electric Aviation Platforms	Cost-benefit modeling	Infrastructure and energy pricing impact

[**Table 1**] presents a descriptive summary of ten key studies included in the meta-analysis, offering a diverse yet cohesive snapshot of the current landscape in electric propulsion research for light aircraft. The studies span a mix of design models, simulations, test flights, operational data, and techno-economic assessments, reflecting a balanced blend of conceptual innovation and real-world validation.

Notably, [3] laid foundational work in the aerodynamic efficiency of VTOL electric aircraft, emphasizing critical parameters like lift-to-drag ratio and hover performance—essential for understanding energy demands during takeoff and landing. In contrast, [1] and [6] contributed valuable operational data, with the former examining battery degradation and charging needs across 15 aircraft and the latter exploring thermal efficiency under high temperatures, which is crucial for assessing tropical viability.

Local relevance is reinforced by [8], whose survey-based study focused on infrastructure readiness and user adoption in the Philippine context. This provides direct insight into real-world barriers and enablers, making it a cornerstone reference for this research. Similarly, [2] and [9] expanded the discussion into sustainability and cost-benefit impacts, with projections of emissions reduction and analysis of energy pricing in hybrid-electric platforms.

From a technological perspective, studies like [4] and [7] explored performance improvements through weight optimization and propulsion architecture enhancements, providing forward-looking insights into next-generation electric aircraft designs. [10] contributed a techno-economic lens, evaluating battery cost trends and maintenance needs, which directly ties into the cost metrics of the meta-analysis. Lastly, [11] added depth through experimental validation of motor systems, reinforcing the feasibility of system integration.

Collectively, these studies provide robust and multidimensional evidence across performance, cost, and environmental dimensions. The combination of simulation, empirical, and regional studies ensures that the meta-analysis is both methodologically sound and practically relevant especially for regions like the Philippines, where tropical environmental conditions and infrastructure limitations must be critically considered.

3.3 Meta-Analysis Findings

Table 2 Meta-Analysis Findings: Performance, Cost, and Environmental Metrics of Electric Light Aircraft

Category	**Metric**	**Pooled Estimate / Finding**
Performance Metrics	Pooled Range (km)	213 km
Performance Metrics	Energy Consumption (kWh/km)	0.85 kWh/km
Performance Metrics	Average Charge Time (hrs)	2.8 hrs
Cost Metrics	Mean Total Cost of Ownership (TCO)	USD 415,000
Cost Metrics	Operating Cost per Hour	USD 85/hr
Cost Metrics	Maintenance Frequency	Every 250 flight hours
Environmental Performance	Battery Degradation Rate (≥35°C)	12–15% annually
Environmental Performance	Battery Degradation Rate (25–34°C)	7–9% annually
Environmental Performance	Corrosion Incidence in Coastal Areas	Higher risk in >70% humidity zones; material fatigue after 3 years

[**Table 2**] summarizes the meta-analysis findings regarding the performance, cost, and environmental metrics of electric propulsion systems for light aircraft, providing a comprehensive overview of their feasibility under real-world and tropical conditions.

Underperformance metrics, the pooled data indicates an average operational range of 213 kilometers, positioning electric aircraft as viable for short-haul and regional missions such as inter-island travel or flight training. The energy consumption rate of 0.85 kWh per kilometer reflects a high level of efficiency, particularly when compared to fossil-fuel-powered aircraft in the same category. Furthermore, the average charging time of 2.8 hours demonstrates growing practicality, especially when supported by reliable ground infrastructure. However, these metrics remain sensitive to environmental conditions, as shown in moderator analyses.

From a cost perspective, electric aircraft exhibit promising economic advantages. The mean total cost of ownership (TCO) stands at USD 415,000, which—while slightly higher than traditional piston-engine aircraft—is offset by significantly lower operational costs. The average operating cost of USD 85 per flight hour and maintenance frequency of every 250 hours underscore the cost-saving benefits of electric systems, largely due to the absence of complex internal combustion engine components and reduced reliance on aviation fuel. These figures suggest strong long-term return on investment, particularly for operators with high utilization rates.

Environmental performance emerges as both a strength and a challenge. In terms of battery degradation, findings reveal that exposure to high temperatures (≥35°C)—common in tropical regions results in annual capacity losses of 12–15%, significantly higher than the 7–9% observed in milder (25–34°C) climates. This highlights the urgent need for temperature-resistant battery systems or improved thermal management strategies. Additionally, corrosion risks in coastal environments present a tangible challenge, with increased material fatigue reported after three years of exposure to humidity levels exceeding 70%. Such environmental stressors necessitate targeted design adaptations, such as enhanced sealing, the use of corrosion-resistant materials, and proactive maintenance protocols.

In summary, the pooled estimates affirm that electric propulsion systems for light aircraft offer substantial performance and cost benefits, especially for short-distance operations. However, their sustainability and reliability in tropical and coastal conditions depend heavily on addressing environmental degradation risks particularly battery aging and corrosion—through technology innovation, infrastructure support, and climate-specific deployment strategies.

3.4 Moderator Effects

Table 3 Moderator Effects on Electric Propulsion Performance in Light Aircraft

Moderator	**Condition**	**Performance Effect**	**Source**
Temperature	35°C	-15% range, 0.3% degradation per cycle	Liu et al., 2024
Temperature	45°C	-20% range, increased cooling demand	Liu et al., 2024
Geographic Region	Urban (80% charging availability)	Stable performance, minimal disruptions	Cabarrubias-Dela Cruz & Tolentino, 2023
Geographic Region	Rural (40% charging availability)	Operational delays, reduced range	Cabarrubias-Dela Cruz & Tolentino, 2023
Geographic Region	Coastal zones	Higher corrosion and casing degradation	Cabarrubias-Dela Cruz & Tolentino, 2023
Geographic Region	High-altitude regions	Improved battery life, better thermal performance	Cabarrubias-Dela Cruz & Tolentino, 2023
Battery Chemistry	NMC (Nickel Manganese Cobalt)	Higher energy density, faster degradation at high temp	Adu-Gyamfi & Good, 2022; Rezende, 2021

Battery Chemistry	LFP (Lithium Iron Phosphate)	Superior thermal stability, 85% capacity at 1000 cycles (35°C)	Adu-Gyamfi & Good, 2022; Rezende, 2021

[**Table 3**] outlines the moderator variables that significantly affect the performance and operational reliability of electric propulsion systems for light aircraft, particularly under conditions relevant to tropical regions like the Philippines. These moderators—temperature, geographic region, and battery chemistry—play a critical role in shaping the real-world effectiveness of electric aircraft technologies.

Temperature emerged as one of the most influential factors. The data shows that at 35°C, aircraft experience a 15% reduction in flight range, and battery cells degrade at a rate of 0.3% per cycle, which is nearly triple the degradation seen in cooler climates [6]. This trend intensifies at 45°C, where range reductions reach 20%, and cooling systems face increased thermal load, further straining energy resources. These results underline the necessity of advanced thermal management solutions and temperature-resilient battery technologies to ensure electric aircraft reliability in hot climates.

The impact of geographic regions further highlights the operational challenges faced in diverse environments. In urban settings, where charging infrastructure availability reaches 80%, electric aircraft show stable performance with minimal disruption [8]. However, in rural areas, where infrastructure support drops to 40%, users face operational delays and reduced range, pointing to the crucial need for equitable infrastructure expansion to support regional aviation. Additionally, coastal deployments introduce another layer of complexity, with increased exposure to humidity and salinity leading to accelerated corrosion and casing degradation—an issue that threatens both airworthiness and safety. In contrast, high-altitude regions provide a more favorable environment, where cooler temperatures contribute to extended battery life and improved thermal performance, suggesting potential advantages in inland deployments.

Lastly, battery chemistry plays a vital role in determining aircraft performance under tropical stressors. Nickel Manganese Cobalt (NMC) batteries offer higher energy densities, making them attractive for longer-range applications. However, they degrade faster in high-temperature environments, reducing the overall system lifespan [1]; [10]. On the other hand, Lithium Iron Phosphate (LFP) batteries exhibit greater thermal stability, maintaining 85% capacity even after 1,000 cycles at 35°C, though at the cost of increased weight and slightly reduced range. This trade-off highlights the need for application-specific battery selection and the development of hybrid storage systems that balance endurance with safety in hot and humid conditions.

Overall, these moderator effects demonstrate that while electric propulsion is promising, performance is not uniform across conditions. Success in deploying electric aircraft in tropical regions will depend on tailored solutions that consider environmental stressors, infrastructure gaps, and battery characteristics. These findings should guide stakeholders—manufacturers, operators, and regulators in optimizing system designs, prioritizing infrastructure development, and implementing climate-specific aviation policies.

3.5 Local Contextualization and Sustainability Implications

While the meta-analysis affirms the feasibility of electric propulsion systems in tropical climates, localized implementation in the Philippines presents both opportunities and challenges. The country's archipelagic layout makes it an ideal candidate for short-haul electric aviation, especially for connecting underserved regions. However, uneven infrastructure distribution with only ~40% charging availability in rural areas—underscores the need for targeted investment in ground-based energy systems. Leveraging the Philippines' high solar potential could enable sustainable off-grid charging stations, aligning the aviation sector with national renewable energy goals.

From a regulatory standpoint, while national agencies such as the Civil Aviation Authority of the Philippines (CAAP) are beginning to recognize the need for sustainable aviation policy, critical gaps remain. Currently, CAAP lacks detailed certification standards for electric aircraft. To facilitate adoption, the agency must align with international frameworks such as those developed by EASA and ICAO while tailoring regulations to the Philippine archipelagic geography. Clear policies on battery safety, performance testing, and airworthiness are essential, along with incentives for R&D and pilot projects.

Importantly, the adoption of electric aviation supports Sustainable Development Goal 13 (Climate Action) by reducing lifecycle emissions and dependence on fossil fuels. Addressing these regulatory, infrastructural, and technological gaps through coordinated public-private collaboration and climate-aligned policymaking will be crucial for ensuring the long-term viability and environmental integrity of electric aircraft operations in the Philippine context.

4. Conclusion

This study has provided a comprehensive, data-driven evaluation of the feasibility of electric propulsion systems for light aircraft operating in tropical climates. The results of the meta-analysis confirm that electric aircraft are viable for short-haul and regional applications, with pooled performance metrics such as an average range of 213 kilometers, energy consumption of 0.85 kWh per kilometer, and an average charging time of 2.8 hours. These figures highlight the operational potential of electric aviation, particularly in archipelagic countries like the Philippines, where short-distance inter-island travel is frequent. Furthermore, cost metrics, specifically a mean total cost of ownership of USD 415,000 and reduced hourly operating expenses indicate strong economic viability in the long term, particularly for high-frequency operators.

However, the study also reveals critical environmental challenges that could impact long-term sustainability and performance. High ambient temperatures typical of tropical regions significantly accelerate battery degradation, with rates reaching 12–15% annually at 35°C, compared to 7–9% in milder climates. Coastal deployments further present increased risks of corrosion and material fatigue due to high humidity and salinity. These findings emphasize the need for climate-specific design considerations and operational strategies to ensure the reliability and durability of electric propulsion systems under tropical conditions.

To support the successful adoption of electric aviation, several stakeholder-specific actions are recommended. Aviation regulators, such as the Civil Aviation Authority of the Philippines (CAAP), should develop safety certification guidelines tailored to electric aircraft, with an emphasis on environmental resilience. Airport authorities and investors should prioritize the installation of reliable charging infrastructure, especially in rural and regional airports, and explore the integration of solar energy to harness the Philippines' renewable energy potential. Manufacturers are encouraged to focus on advancing battery chemistries with greater thermal stability, such as Lithium Iron Phosphate (LFP), and adopt corrosion-resistant materials suited for coastal environments. Additionally, academic institutions and research bodies should initiate localized demonstration projects to collect operational data and further refine tropical feasibility assessments.

Ultimately, while the implementation of electric propulsion systems in tropical aviation is feasible, it is contingent upon proactive infrastructure development, regulatory readiness, and targeted technology adaptation. By addressing these region-specific challenges, the Philippine aviation sector has the opportunity to become a leader in sustainable air mobility, contributing meaningfully to global climate goals, particularly Sustainable Development Goal 13: Climate Action.

4.1 Recommendations

To accelerate the adoption of electric propulsion systems in tropical aviation, it is recommended that industry stakeholders support pilot programs using the best-performing battery systems, particularly those with demonstrated thermal stability such as Lithium Iron Phosphate (LFP). These pilots can validate performance under real-world tropical conditions and build confidence for broader deployment. Policymakers should be guided to establish clear regulations on the importation, certification, and safe handling of electric aircraft batteries while also integrating infrastructure zoning guidelines to ensure strategic placement of charging stations, especially in regional and coastal airports. Finally, academic institutions and research agencies should be encouraged to lead localized studies on battery cooling technologies and corrosion-resistant materials, enabling tailored solutions that address the unique environmental stressors of tropical climates like the Philippines.

4.2 Limitations

While this study offers valuable insights into the feasibility of electric propulsion systems for light aircraft in tropical climates, several limitations must be acknowledged. First, there was significant heterogeneity in reporting standards across the included studies, particularly in how performance metrics such as range, battery efficiency, and maintenance intervals were measured and reported. This variability limited the ability to make perfectly uniform comparisons and may have introduced minor inconsistencies in the pooled estimates. Second, the availability of long-term performance data specific to tropical climates remains limited. Most of the included studies focused on short-term testing or simulations, with only a few providing data collected under sustained high-temperature and high-humidity conditions. As a result, projections on battery degradation and corrosion impacts may underrepresent real-world wear over time. Lastly, there is a notable lack of Philippine-based empirical trials or operational case studies involving electric aircraft. This gap restricts the contextual accuracy of the findings and highlights the need for local pilot projects to validate performance, cost, and environmental outcomes within the country’s unique geographic and climatic conditions.

4.3 Future Research

To build on the findings of this study, future research should focus on generating more context-specific and long-term evidence. First, longitudinal studies on battery performance and degradation in tropical aviation operations are essential to better understand how sustained exposure to heat and humidity affects battery lifespan, efficiency, and safety. These studies would provide critical data for predicting maintenance schedules and optimizing battery replacement cycles. Second, a comprehensive cost-benefit analysis of implementing solar-powered charging microgrids in rural airports should be conducted. This would help determine the financial and environmental viability of renewable energy solutions in off-grid or infrastructure-limited regions, which are common in archipelagic nations like the Philippines. Lastly, researchers should prioritize the development of localized performance models that account for regional climate variables, flight profiles, and operational constraints. Such models would enable more accurate forecasting, planning, and policy-making, supporting the practical integration of electric aircraft into the Philippine aviation landscape.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this study. No financial, professional, or personal relationships have influenced the design, execution, or interpretation of the research presented in this manuscript.

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