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Defining Level of Service Standards for Subsidised Air Transport in  
Colombia.

School of Aerospace, Transport and Manufacturing  
Air Transport Management

Master of Science (MSc)  
Academic Year: 2024 - 2025

Supervisor: Dr. Romano Pagliari  
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the degree of Air Transport Management

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## **Abstract**

Air transport is vital for regional development and social inclusion in Colombia, especially where road and river connectivity are limited or entirely absent. Despite the strategic role of subsidised air routes operated by SATENA, Colombia lacks a structured framework to assess whether these services adequately meet the needs of isolated communities. This thesis addresses that gap by developing a classification framework to evaluate service levels on subsidised air routes, using a combination of operational, geographic, and socioeconomic indicators.

A mixed-methods approach was applied across five case study routes selected to reflect Colombia's geographic and demographic diversity. Quantitative data were gathered from national aviation and statistical agencies, while qualitative insights were obtained through questionnaires directed at both stakeholders and SATENA users. Service quality variables were weighted using the Analytic Hierarchy Process (AHP) and combined into a flexible classification model.

The results showed significant variation in service adequacy across the five routes. While some services aligned with regional needs, others fell short, particularly in areas with high poverty and limited ground transport. The findings demonstrate that air connectivity in Colombia remains essential but uneven, and that current resource allocation could be improved.

This thesis provides a practical framework for assessing subsidised air services and offers clear implications for policy and planning. By incorporating both operational metrics and user perspectives, the model supports data-driven decisions about air transport provision in remote regions of Colombia.

**Sponsor company:** Aerocivil Colombia

### **Keywords:**

Subsidies, PSO, regional connectivity, service level framework, SATENA, remote communities, multicriteria analysis.

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## List of Abbreviations

|        |                                                       |
|--------|-------------------------------------------------------|
| AHP    | Analytic Hierarchy Process                            |
| ASAE   | Airports for Essential Air Services                   |
| COP    | Colombian Peso                                        |
| DANE   | National Administrative Department of Statistics      |
| DOT    | Department of Transportation (United States)          |
| EAS    | Essential Air Services                                |
| ETC    | Essential Transport Connectivity                      |
| GCI    | Global Connectivity Index                             |
| GIS    | Geographic Information System                         |
| IATA   | International Air Transport Association               |
| KPI    | Key Performance Indicator                             |
| LOS    | Level of Service                                      |
| MCDA   | Multi-Criteria Decision Analysis                      |
| MPI    | Multidimensional Poverty Index                        |
| OAG    | Official Airline Guide                                |
| PSO    | Public Service Obligation                             |
| RAAP   | Regional Aviation Access Program                      |
| RAS    | Rural Air Services                                    |
| RASS   | Remote Air Services Subsidy                           |
| RCS    | Regional Connectivity Scheme                          |
| SATENA | Servicio Aéreo a Territorios Nacionales               |
| UPIT   | Unidad de Planeación de Infraestructura de Transporte |
| WSM    | Weighted Sum Model                                    |

# 1 Introduction

## 1.1 Research background

Access to reliable air transport is essential for regional development in geographically isolated areas, particularly where ground transport is either non-existent or constrained (Leão e Silva et al., 2022). For communities located in remote parts of Colombia, such as the Amazon, Orinoquía, and the Pacific Coast, geographic isolation is a fundamental barrier to social and economic inclusion. These regions are often characterised by dense forests, mountainous terrain, and limited infrastructure, making land or river transport impractical or impossible for large parts of the year (Ivarsson et al., 2023).

In such contexts, air transport becomes a vital lifeline. It supports access to education, healthcare, administrative services, and economic opportunities, while also enabling the delivery of essential goods such as food and medicine (IATA, 2019). Recognising this, the Colombian government subsidises air services operated by SATENA, a state-owned airline, to ensure basic connectivity for communities underserved by commercial carriers (Fageda et al., 2018). These routes, many of which are unprofitable in commercial terms, play a strategic role in promoting territorial integration and national cohesion.

Despite the clear social function of subsidised air services, Colombia currently lacks a systematic framework to define what constitutes an adequate level of service of these routes. As a result, decision-making is often influenced by political or operational constraints rather than based on a consistent assessment of regional needs. This can lead to inefficiencies in the allocation of subsidies, unequal treatment across regions, and under or overprovision of services on certain routes (Leao et al., 2022).

Internationally, various countries have implemented structured models to assess and regulate subsidised air transport. For instance, the U.S. Essential Air Services (EAS) programme and the European Union's Public Service Obligation (PSO) framework both include criteria to define service expectations, evaluate cost-effectiveness and ensure transparency (Wittman et al., 2016). These models

highlight the importance of aligning subsidies with clear service benchmarks and regional policy goals.

In the Colombian context, several studies have outlined the importance of regional air connectivity (Díaz Olariaga, 2021; Fageda et al., 2019). However, the academic literature has yet to develop a framework to guide the evaluation of service levels in subsidised air transport. This gap becomes critical as the government seeks to improve transparency, performance, and equity in the use of public funds.

## **1.2 Motivation and research problem**

In Colombia, subsidised air transport plays a crucial role in ensuring connectivity for communities located in remote and geographically isolated regions. While SATENA operates many of these routes, there is no consistent framework guiding what constitutes an adequate level of service. As a result, communities often experience irregular or insufficient flights, and policymakers lack clear criteria for evaluating whether current services meet local needs.

The motivation for this research arises from the need to address these gaps. On a practical level, operators and regulators face the challenge of delivering appropriate services with optimal resources allocation. From a social perspective, inadequate air connectivity can limit access to essential services, deepen territorial inequalities, and hinder economic development in regions that depend heavily on aviation.

Although other countries have implemented models for subsidies routes, these cannot be directly transferred to Colombia due to its unique geography, regional disparities, and institutional context. A locally adapted approach is needed. Therefore, the research problem centres on the lack of a clearly defined framework to assess and guide service levels in Colombia's subsidised air transport network. Without such a framework, it is difficult to ensure that resources are distributed effectively, and that communities receive the connectivity they need.

### **1.3 Aim and objectives**

This research aims to develop a service level framework for subsidised air transport in remote Colombian regions that supports efficient connectivity.

The main objectives of the research are:

1. To evaluate the current provision of subsidised air services across selected routes in Colombia, focusing on frequency, scheduling, capacity, and coverage.
2. To assess the connectivity needs of remote communities served by the selected case study routes, considering their geographic, demographic, and socioeconomic conditions.
3. To identify and prioritise service quality variables based on stakeholder input and operational relevance.
4. To develop a classification framework that defines service levels using weighted service variables.
5. To apply the framework to case study routes and evaluate how current services align with the defined service levels.

### **1.4 Structure**

This thesis is organised into five different chapters. Firstly, the introduction outlines the importance of air connectivity for remote communities in Colombia and the challenges posed by the country's geography and infrastructure. It presents the research problem, motivation, aim and objectives.

Secondly, the literature review examines key themes including subsidies air transport policies, service level frameworks, and regional accessibility. It also reviews international approaches to connectivity and highlights research gaps relevant to the Colombian situation.

In third place, the methodology chapter details the research design, including case study selection, data collection methods, and analytical approaches. It presents both quantitative and qualitative components and outlines ethical considerations.

Moreover, the results and discussion chapter presents the findings from the operational assessment and community needs analysis. It introduces the service level framework and applies it to the selected case study routes, highlighting key connectivity challenges and policy implications.

Finally, the conclusions chapter summarises the main findings, offers policy recommendations to enhance subsidised air services in remote areas, and describes suggestions for future research on improving regional air transport connectivity.

## **2 Literature review**

### **2.1 Introduction**

This section aims to contextualise subsidised air transport services as implemented in various regions around the world, analysing the different models of state intervention, policy objectives, and operational structures. Particular attention is given to international frameworks that guide the planning and classification of these services.

The review also explores how service levels are defined and evaluated, highlighting the criteria and benchmarks commonly used to assess effectiveness. Through this literature review, existing models and gaps in current practice will be identified, providing the foundation for the proposed classification framework for subsidised air services.

### **2.2 Air transport and regional connectivity**

The role of air transport in enhancing regional connectivity has been widely studied, especially in relation to its capacity to link remote or underserved regions to global networks. Scholars generally agree that connectivity is a crucial factor in assessing the effectiveness of air transport systems (Arvis & Shepherd, 2011). Díaz Olariaga (2021) emphasises the importance of regional airports as critical transport nodes that foster accessibility and promote social cohesion by enabling the movement of people, goods, and services. These airports often act as gateways for isolated communities and are the only viable mode of connection.

Recent studies have also examined the impact of air route expansion on regional accessibility. For instance, Oh and Cho (2024) assessed accessibility improvements from new route configurations and found that while individual routes had varied impacts, combination of routes significantly enhanced accessibility. This highlights the importance of considering network effects when planning air services for regional development.

From an economic perspective, increased regional traffic has been associated with higher per-capita income and broader economic growth (Çağrı Özcan,

2014), suggesting that better air connectivity can stimulate local economies. Likewise, Lenaerts et al. (2021) argue that air transport contributes to shaping economic geography and productivity, particularly by enhancing regional competitiveness and enabling faster movement of labour and capital.

The geographic and infrastructural challenges facing remote or low-growth regions are also another important theme in the literature. According to the European Commission (2017), such areas often suffer from poor accessibility due to natural barriers and insufficient infrastructure. In this context, Ceulemans et al. (2025) note that air transport is uniquely positioned to address these challenges as it is relatively independent from the physical terrain.

One of the major challenges in initiating air services in communities with poor connectivity and limited accessibility is the consistently low demand, which significantly undermines the profitability and long-term viability of such routes (Sindhwani et al., 2024). Added to that, operating costs are generally higher for regional routes served with smaller aircraft, as costs per seat increase in comparison with bigger aircraft (Bråthen, 2011; Chen et al., 2025). Fuel costs are also higher in remote locations because of the need of transportation (Eisenhut et al., 2021). Given that situation, the majority of airlines are not keen on serving these routes, which significantly affects the connection between those remote regions.

To address these issues, governments and regulatory bodies have developed policy instruments, including subsidy programmes and public service obligations, to ensure minimum level of service in strategically important but commercially unviable regions (Díaz Olariaga, 2021). These frameworks are created to guarantee connectivity and to promote equity and territorial integration. The following section explores these subsidy mechanisms in more depth, reviewing international models and practices.

## **2.3 Subsidised air services**

Fageda et al. (2018) describe subsidised services as those targeting “remote regions, isolated communities, and non-commercial routes or destinations”

(p.65), which require established public policies to ensure connectivity and guarantee minimum service levels for passengers. Numerous studies have sought to define and classify these types of routes. For instance, Leão e Silva et al. (2021) categorised over a thousand subsidised routes based on geographical conditions, finding that communities in islands, forests and polar regions are particularly reliant on air transport.

Industry experts typically group subsidised air services into four main categories: route-based, passenger-based, airline-based, and airport based-policies (Fageda et al., 2018). Many countries implement a combination of these approaches depending on regional needs and political objectives. Route-based schemes establish minimum service requirements, such as frequency, schedules, and aircraft type for specific routes. When no commercial operator is willing to serve the route, subsidies are provided to a designated carrier to offset operational losses (Mueller, 2021). Examples of this approach are widely seen in the European Union and the United States, and will be examined in detail in the next section.

Passenger-based policies involve fare discounts for residents of remote or isolated regions. Spain leads in this area, offering significant subsidies to residents flying from the Canary Islands, Balearic Islands, Ceuta, and Melilla (Jiménez et al., 2023). Similar models exist in Portugal, Scotland, and Ecuador. Jiménez et al. (2023) argue that funds allocation must be based on route-level analysis, as fare levels are often shaped by the intensity of airline competition.

Airline-based policies involve state-owned airlines mandated to serve essential routes. In these cases, the government determines the network structure, fare caps, and service frequencies (Fageda et al., 2019). While this can guarantee access, it often results in lower operational efficiency and suboptimal resource due to the lack of market competition. Examples include MASwings in Malaysia and SATENA in Colombia (Fageda et al., 2018).

Airport-based policies, on the other hand, focus on attracting or retaining air services through airport incentives. These may include reductions in airport charges, marketing support, or direct financial incentives to airlines (Valdes et al.,

2024). Recent studies highlight how regional airports implement these strategies to boost passenger numbers (Bilotkach & Bush, 2020; Warnock-Smith et al., 2025). However, when demand is highly seasonal, it is challenging to achieve long-term sustainability of such incentives.

Given the thesis's focus on defining an evaluative framework for subsidised service levels at the route level, the next section will explore route-based policies in more depth.

### **2.3.1 Public Service Obligation (PSO) routes**

The Public Service Obligation (PSO) scheme in Europe serves as a mechanism for states to guarantee air connectivity where commercial operations are unprofitable but socially necessary. Established under the Regulation EC No 1008/2008, PSOs allow governments to impose service requirements and provide financial compensation to ensure connectivity. There are two types: Open PSOs, where any airline may operate without exclusivity, and Restricted PSOs, where a single operator is selected via a public tender and may receive subsidies to offset operational costs (Leandro et al., 2021).

The number of PSO routes in Europe has grown significantly since the 1990s. While there were 64 in 1997 (Williams & Pagliari, 2004), mainly in France and Ireland, the total reached 165 by March 2024 (see Figure 2-1) (European Commission, 2024). Despite the programme's expansion, challenges remain in the implementation. Merkert and O'Fee (2013) note that some authorities adopt generic PSO templates without tailoring them to local conditions, potentially reducing effectiveness. They also highlight the need for proactive engagement between tenders to lower entry barriers for new operators.

Additionally, PSO contracts often hinder innovation due to rigid conditions and limited incentives. As Merkert and O'Fee argue (2016), contracts should distribute equally risk and reward, allowing operators to benefit from revenue gains driven by their own marketing or service improvements. Without these mechanisms, carriers lack motivation to enhance route performance.

From a pricing perspective, PSO routes have not consistently delivered lower fares. Fageda et al. (2017) found that capped prices on PSO routes can be higher than what the market might offer, particularly since most contracts are awarded to regional airlines with higher operating costs. In contrast, alternative subsidy models such as resident fare discounts may be more effective at reducing passenger prices.

Overall, while PSOs have helped maintain essential air links, especially in remote areas, there is room for improvement regarding efficiency, competition, and adaptability within the framework to better serve regional development goals.

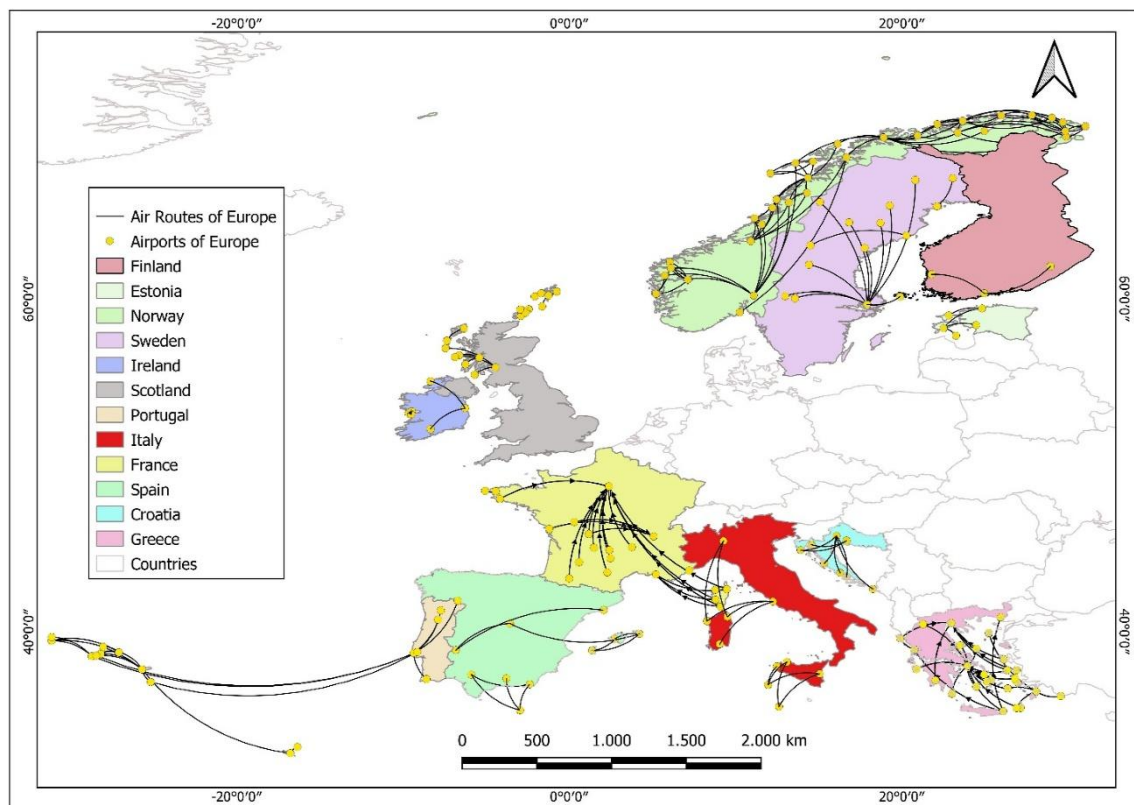


**Figure 2-1.** PSO routes in the European Community (Leão e Silva et al., 2022).

### 2.3.2 Essential Air Services (EAS)

The Essential Air Services (EAS) program was established in the United States following the Airline Deregulation Act of 1978 to ensure continued air service to small and remote communities. Özcan (2014a) outlines how regional carriers are subsidised by the U.S. Department of Transportation (DOT) to operate

unprofitable routes, providing critical connectivity to larger hubs. Unlike Europe's PSO, EAS mandates that services connect small airports to larger ones. Özcan (2014b) provides empirical evidence showing that sustaining EAS flights correlates with increases in per capita income in those communities.

Wittman et al. (2016) critique the lack of connectivity evaluation in EAS tenders and propose incorporating a Global Connectivity Index (GCI) analysis to improve value for money. They argue that making onward connectivity a selection criterion would enhance economic effectiveness. Park & O'Kelly (2017) examine how rigid eligibility rules for EAS services fail to reflect local variations in accessibility and carrier dynamics, which affect passenger experience and airport usage.

The U. S. Government Accountability Office (2019) explores recent statutory changes to the EAS program, such as subsidy caps and minimum passenger thresholds, and highlights how waivers have maintained the number of supported communities despite these new constraints. The report also discusses industry challenges, especially pilot shortages and wage increases, which raise operational costs and push the limits of subsidy caps.

Finally, Özcan (2014a) also examines the political and economic controversy surrounding the program. While advocates highlight EAS's role in promoting accessibility and regional equity, critics argue that it exemplifies inefficient public spending, as the benefits are concentrated in less than 1% of the population while costs are distributed nationally.

### **2.3.3 Other subsidy schemes**

Beyond the well-established frameworks in the European Union and the United States, several other countries have developed their own subsidy schemes to support air connectivity in remote or underserved areas.

In Australia, the Regional Aviation Access Program (RAAP) and its Remote Air Services Subsidy (RASS) component provide essential financial support to communities that rely on air travel for access to goods and services, especially during the wet season (Hromádka, 2017).

In Malaysia, the Rural Air Services (RAS) scheme operates under a PSO agreement with MASwings. It supports connectivity for 40 routes across Sabah and Sarawak, fully subsidised by the government, serving communities with no viable alternatives (Ministry of Transport Malaysia, 2025).

India's Regional Connectivity Scheme (RCS), launched in 2016, seeks to enhance access to underserved airports by combining subsidies and fare caps. However, the scheme has struggled to deliver significant benefits for truly remote regions, particularly in the northeast, due to its airport-focused approach and lack of tailored incentives (Das et al., 2020).

New Zealand's Essential Transport Connectivity (ETC) scheme, introduced in response to COVID-19, aimed to preserve essential regional air services by financially supporting operators facing crisis challenges. While helpful in the short term, the programme highlighted the need for long-term strategies to ensure resilience and connectivity for small and remote communities (Wu et al., 2025).

These programmes demonstrate how air service subsidies can strengthen regional economies, ensure social inclusion, and maintain critical lifelines. Despite these efforts, many countries still lack defined frameworks or comprehensive regulatory mechanisms. In some cases, the allocation criteria, funding structures, or long-term sustainability plans remain underdeveloped.

The next section explores the case of Colombia, where challenges remain in implementing an optimised air subsidy strategy.

## **2.4 The Colombian context**

Colombia's air transport industry, which forms the case study for this research, underwent significant liberalisation in the early 1990s. This shift followed global trends in aviation deregulation and included the entry of private operators, privatisation of national airlines, deregulation of fares, and the expansion of bilateral air service agreements. Díaz Olariaga and Alonso-Malaver (2022) provide a detailed overview of this transformation, highlighting its long-term impact on regional connectivity and the institutional framework of Colombian aviation.

### 2.4.1 Geography and regional aviation

The Colombian airport network spans the country's five natural regions: Amazonia, Andean, Caribbean, Orinoquia and Pacific. These areas differ substantially in terms of climate, topography, ecosystems, and socioeconomic structures, shaping their respective transport needs and development trajectories. Díaz Olariaga and Carvajal (2016) underscored the extent to which this geographical diversity necessitates a flexible and decentralised air transport strategy. Figure 2-2 provides an overview of these regions, showing their altitudes and how the airport network is distributed across the national territory.

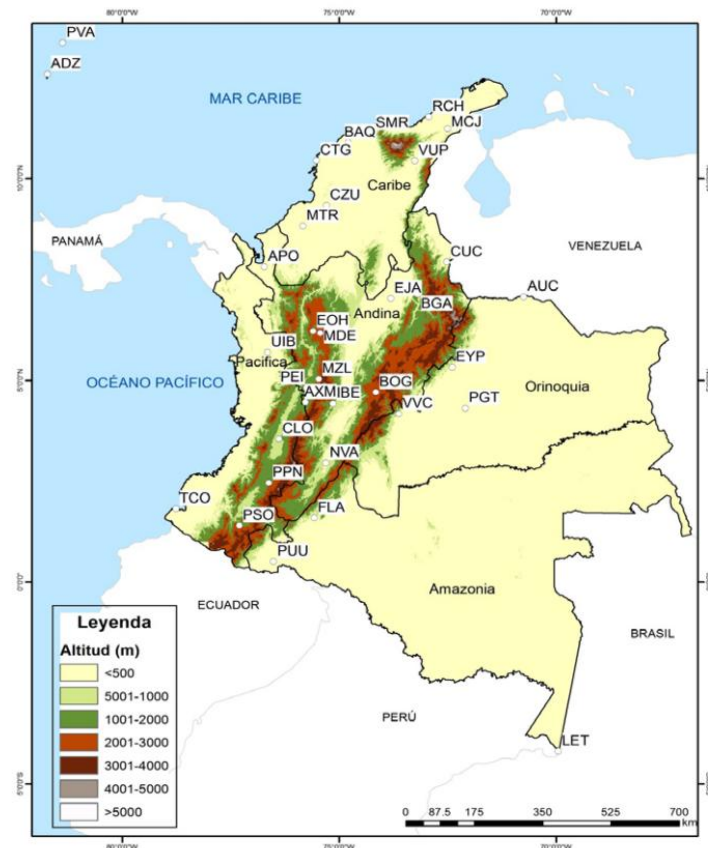


**Figure 2-2.** Geography of the Colombian airport network (Díaz Olariaga & Carvajal, 2016).

Colombia's physical geography poses major challenges to connectivity. The Andean Mountain range divides into three branches that run across the country, while the archipelago of San Andrés, Providencia, and Santa Catalina lies 775 km from the mainland. Additionally, approximately 42% of the national territory is

covered by the Amazon rainforest, making ground access particularly difficult in those areas. As Díaz Olariaga and Alonso-Malaver (2022) explain, these natural barriers are compounded by a lack of rail transport and an underdeveloped road system. In many areas, air transport becomes not only a competitive option but a necessity.

Díaz Olariaga (2021) argued that, in the absence of a national passenger rail network and given the poor coverage and capacity of existing roads, aviation has become essential for integrating peripheral regions. This is particularly evident in the Amazon and Pacific regions, where river navigation is seasonally limited and land routes are unsafe or impractical. In such cases, air transport serves as the only reliable connection to the rest of the country.

The role of regional airports has therefore become critical. Leão e Silva et al. (2022) referred to these air services as “lifeline routes”, emphasising their function in ensuring access to basic public services, markets, and social infrastructure. In the Colombian case, analysis by Olariaga et al. (2018) shows that air travel is often preferred for routes over 200 km, and even for shorter distances in mountainous areas. This preference is linked to the geographic and topographic constraints, which influence travel time, cost, and reliability.

#### **2.4.2 Subsidised air services**

To address these structural connectivity issues, the Colombian state has adopted what has been described as an airline-based model of public service provision. Under this approach, a state-owned airline is responsible for connecting regions where private operators are unable or unwilling to serve. SATENA, founded with this mission, remains central to this policy framework. According to Fageda et al. (2018), SATENA’s mandate is to provide essential air services to areas with limited access, where operations are typically unprofitable or logistically difficult due to security concerns or infrastructure limitations.

As of 2023, SATENA operates 49 domestic routes, of which 38 are part of the *Banco de Rutas Sociales* (Social Route Network). However, the airline acts as the sole operator and thus receives public subsidies on only 30 to 32 of these,

depending on the season (Aerocivil, 2023). Figure 2-3 presents a visualisation of SATENA's current network, showing the extent of coverage across the national territory. Aerocivil (2023) underscores that public funding is essential to maintain these subsidised routes, which are vital for connecting remote areas and ensuring access to basic services.

The criteria for route selection and prioritisation are based on a multi-dimensional assessment developed by Aerocivil. These include demographic factors, existing connectivity, airport infrastructure, security conditions, and social and economic indicators. Environmental and strategic considerations are also included. Economic and social factors receive the highest weighting in the evaluation model, as detailed by Aerocivil (2023).

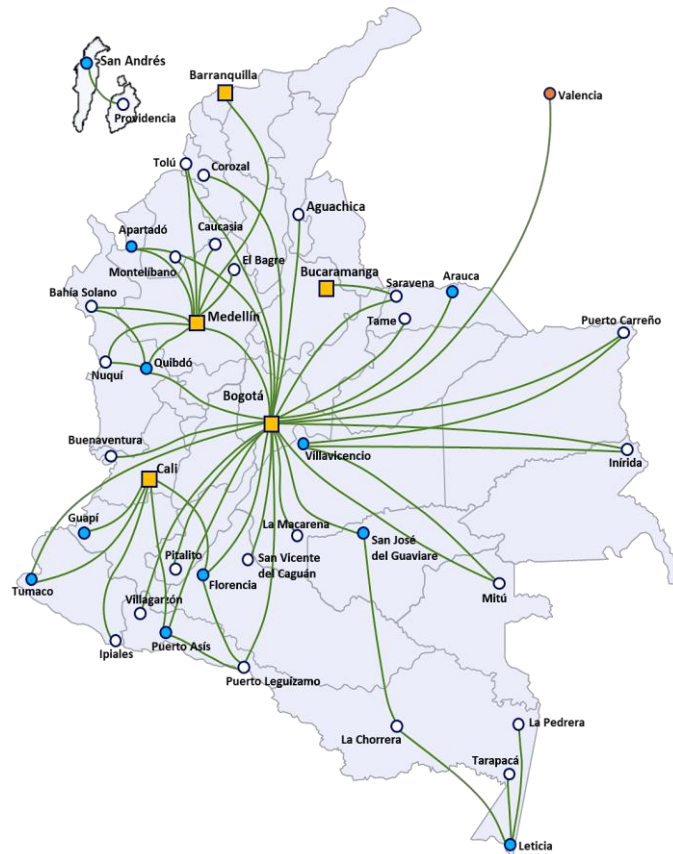


**Figure 2-3.** SATENA's current network (Aerocivil, 2023).

### 2.4.3 Current regulatory framework and future outlook

Since liberalisation began in 1992, Colombia has moved toward a mixed model in which most airports are operated by private concessionaires, while the state retains responsibility for planning, regulation, and subsidised services. The current model aims to balance efficiency, coverage, and public interest. As Díaz Olariaga and Alonso-Malaver (2022) have pointed out, although private carriers dominate the domestic market, with low-cost and full service airlines accounting for approximately 95% of passengers in 2018, essential air services remain a core public responsibility.

Aerocivil continues to lead national aviation policy and investment planning. One of its priorities has been the upgrading of airport infrastructure, particularly in underserved areas. The most recent strategic plan highlights the need to improve airside facilities at aerodromes used for social routes, ensuring compliance with safety and operational standards (Aerocivil, 2023).

In order to modernise and optimise its approach to subsidised air transport, Aerocivil and SATENA have proposed a new methodology for identifying and prioritising essential routes. Based on Resolutions No. 3442 (2016) and No. 3175 (2018), the framework outlines three levels of prioritisation: routes currently operated by SATENA, those included in SATENA's short and medium-term expansion plans, and those connected to airports listed in the *Aeropuertos para los Servicios Aéreos Esenciales* (ASAE) programme. Aerocivil (2023) provides the full operational criteria and justifications for this updated system.

This renewed policy direction is aligned with Colombia's *Plan Nacional de Desarrollo 2022-2026*, titled *Colombia, Potencia mundial de la vida* (Departamento Nacional de Planeación, 2023). The plan recognises air connectivity as a fundamental right and means of promoting social inclusion, public service access, and regional equity.

To implement this vision, SATENA began an ambitious expansion plan in 2024. The strategy is based on a hub-and-spoke model with four new bases: Medellín, Cali, Villavicencio, and Bucaramanga (see Figure 2-4). SATENA's fleet will be

expanded with the acquisition of eight Twin Otter aircraft in three phases, which will allow the launch of 105 new routes by the end of the plan's horizon. According to SATENA, the plan is ongoing, with some new routes already operational and full implementation expected by 2026. In recognition of its efforts to improve accessibility and territorial integration, SATENA was named “Leader in Enhancing Accessibility in Colombian Air Travel” by the Global Brand Frontier Awards 2024 (Boston Brand Research & Media, 2025).

This expansion reflects the Colombia’s long-term commitment to ensuring that all citizens, regardless of location, have access to affordable, reliable, and safe air transport. It also underscores how government decisions play a key role in shaping how people move around in a country marked by geographic and economic divides.

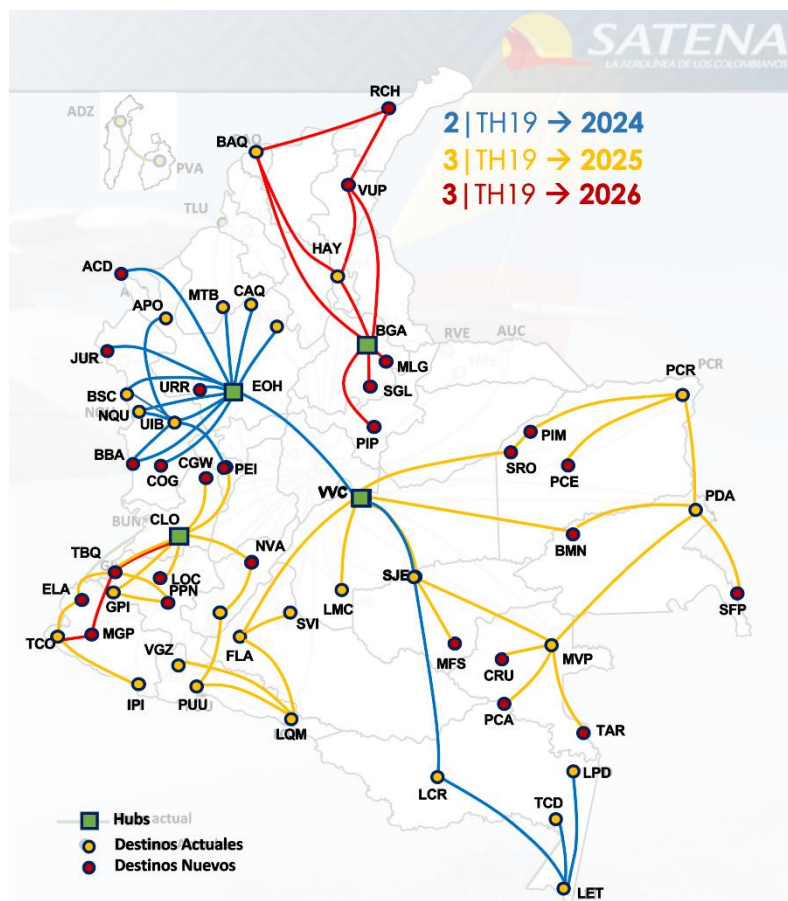


**Figure 2-4.** SATENA’s expansion plan from the Bogotá conference in 2024.

## **2.5 Service level variables in air transport**

The second major theme of this literature review focuses on the concept of service levels in air transport, especially in the context of regional and subsidised operations. While considerable research has explored service quality in commercial aviation, little attention has been given to how service levels are defined, measured, and applied, particularly in PSO networks.

### **2.5.1 Defining service levels in air transport**

Much of the literature in air transport concentrates on service quality rather than on the actual Level of Service (LOS) provided to a community. Service quality is typically divided into phases: pre-flight, in-flight, and post-flight services. For example, Chandra Mahapatra & Bellamkonda (2023) categorise these services as ticketing, airport ground services, in-flight amenities, and destination services. However, this approach focuses on the perceived experience rather than the availability or adequacy of the service itself.

Industry experts often rely on models such as SERVQUAL, which uses a five-dimensional framework (tangibles, reliability, assurance, empathy, and responsiveness). Babakus & Boller (1992) argue that SERVQUAL model has several limitations and that the service quality dimensions may vary depending on the context studied.

By contrast, the definition of “service levels” includes tangible operational metrics such as flight frequency, aircraft type, seat capacity, and network structure. Bråthen & Eriksen (2018) emphasise the importance of defining LOS in PSO schemes to ensure fair and predictable connectivity. They note that LOS definitions should balance accessibility needs with cost efficiency and propose criteria such as access to the capital, international airports, advanced healthcare, and county administration.

Pinchemel et al. (2022) note that airlines aim to meet demand by adjusting flight frequency or deploying larger aircraft, highlighting the straight relation between service levels and operational costs. Kölker et al. (2016) further propose using

flight frequency and aircraft movement forecasting to match capacity with anticipated demand.

Although IATA (2022) provides best practice guidelines for level of service at airports, covering queueing time, space for passengers, and seating, there is no accepted framework for defining LOS for airline services. Bråthen & Eriksen (2018) underline this point, stating that most current definitions are based on short-term political interests rather than systematic evaluations.

### **2.5.2 Applications to regional and subsidised services**

Applications of LOS analysis are very relevant for regional and subsidised air transport services, where ensuring adequate connectivity is the main objective. Researchers have proposed various metrics to evaluate LOS in both commercial and subsidised contexts. For example, Matisziw et al. (2012) analyse the U.S. EAS programme and measure accessibility by calculating the distance from each community to its designated hub. Additionally, they assess outbound seat availability at each hub, assuming that higher seat volumes indicate stronger integration into the national network.

Alkhatib and Migdadi (2018) identify a range of key performance indicators (KPIs) for airline operations, including the number of scheduled departures, destinations served, available seat capacity, load factors, aircraft types, and number of crew per aircraft. These indicators, while often used in commercial aviation, are also relevant for evaluating the effectiveness of subsidised routes.

Bråthen and Eriksen (2018) apply a more structured approach for evaluating LOS in Norway's PSO routes. Their methodology incorporates operational and socioeconomic indicators, including latest arrival time at destination and earliest return flight. These indicators are evaluated against surface transport alternatives to assess overall accessibility and cost-effectiveness.

Similarly, Wittman (2014) evaluates air service accessibility in the U.S. metropolitan regions by constructing a connectivity index that accounts for both nonstop and connecting flights, with higher weight assigned to routes serving major hubs. His Airport Connectivity Quality index captures the quality of service

available at each airport and underscores the importance of network integration over isolated regions.

In Finland, Adler et al. (2025) assess air accessibility supported by PSOs using KPIs such as number of passengers transported and weekly flight frequencies. Their comparative analysis includes road and rail alternatives and evaluates dimensions such as reliability, cost, and availability. Their findings emphasise that air connectivity plays a vital role in supporting remote communities and should be monitored through consistent indicators.

## **2.6 Research gap**

Despite these advances, a unified framework for defining service levels in air transport remains absent. Most evaluations are based on country-specific criteria shaped by institutional priorities rather than standardised benchmarks. This absence is particularly notable in the case of Colombia, where subsidised air services play a critical role in connecting remote and underserved regions.

As the provision of these services is managed through SATENA, the reliance on a single state-owned airline raises concerns regarding efficiency and transparency of public fund allocation. Without a clear LOS framework to guide the design, frequency, and capacity of subsidised routes, service provision may not align with actual community needs or cost-effectiveness goals. This lack of a systematic, evidence-based approach limits the ability to evaluate whether current subsidies are achieving their intended social and economic objectives. It also hinders comparisons with similar schemes in other countries and the development of performance benchmarks. Therefore, there is a need to establish a transparent and standardised framework for defining LOS in the Colombian context.

Addressing this gap could enable better public investments, enhance regional inclusion, and foster long-term sustainability in Colombia's subsidised air transport system, while also contributing to international service level standards in aviation.

## **3 Methodology**

### **3.1 Introduction**

To address the research problem and meet the objectives outlined in the introduction and literature review chapters, a structured and phased methodology was adopted. This approach integrates both quantitative and qualitative approaches to evaluate current air transport services in Colombia, understand community needs, develop a classification framework, and apply that framework to selected case study routes. The chapter is structured to first explain the overall approach, followed by details on data collection, analysis methods, and ethical considerations.

### **3.2 Methodological approach**

This research adopts a mixed-methods approach, combining quantitative and qualitative techniques to provide a holistic understanding of the adequacy of subsidised air services in remote regions of Colombia. This methodological design enables both an evaluation of service characteristics (quantitative) and an exploration of lived experiences and stakeholder perspectives (qualitative), ensuring that technical performance is analysed in the context of real-world needs.

The study is structured into four sequential phases, each corresponding to specific research objectives and analytical processes. Figure 3-1 below outlines the methodological design and shows how each phase addresses one or more of the five objectives.

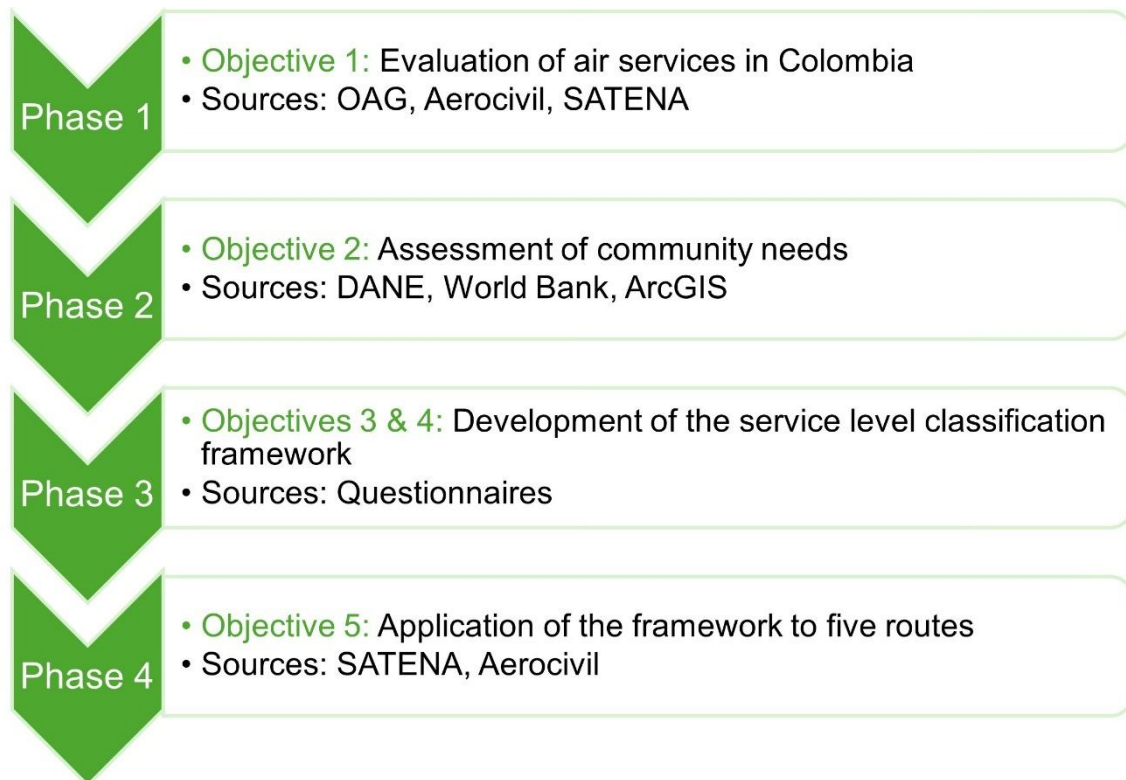


**Figure 3-1.** Methodological approach.

### 3.2.1 Quantitative methods

Quantitative methods are central to Phases 1, 2, and 4, providing measurable insights into both air service characteristics and community-level indicators:

- **Phase 1 – Evaluation of air services (Objective 1):** A structured analysis of SATENA's current air services, including route schedules, aircraft type, and load factors is carried out. Data from OAG, Aerocivil, and SATENA is used to identify operational patterns and service gaps.
- **Phase 2 – Assessment of community needs (Objective 2):** Indicators such as population distribution, accessibility, and the Multidimensional Poverty Index (MPI) are analysed to evaluate regional connectivity challenges. Spatial data is processed using ArcGIS (2025) to calculate 3-hour drive catchment areas, a metric to define functional accessibility zones in transport studies (Birolini et al., 2024).
- **Phase 4 – Application of the framework (Objective 5):** The final evaluation classifies the adequacy of services on selected case study

routes using a Weighted Sum Model (WSM). This enables a comparison of service quality across multiple variables and helps identify where interventions are most needed.

### **3.2.2 Qualitative methods**

Qualitative approaches are used in Phases 2, 3, and 4 to incorporate lived experiences and stakeholder knowledge into the analysis:

- **Phase 3 – Development of a service level framework (Objectives 3 and 4):** A questionnaire targeting industry stakeholders was used to identify relevant service variables and assess their relative importance. The responses were analysed using Multi-Criteria Decision Analysis (MCDA) techniques, including the Analytic Hierarchy Process (AHP), a pairwise comparison method that derives weights for each criterion (Dožić & Kalić, 2014).
- **User perceptions (Phases 2 and 4):** A separate questionnaire was distributed to SATENA users to gather perceptions of service adequacy, accessibility, and satisfaction. This primary data was used to validate results of the framework and provide an understanding of local needs.

The integration of these methods strengthens the study's ability to generate practical, evidence-based recommendations for improving air connectivity in remote Colombian regions, as mixed methods are particularly well-suited to understanding processes in complex implementation contexts (Palinkas et al., 2010).

### **3.3 Data collection**

This study relies on both secondary and primary data sources to evaluate subsidised air services in Colombia and assess the needs of remote communities. Secondary data provides quantitative evidence on operational and socioeconomic indicators, while primary data offers insights from industry experts and service users.

### 3.3.1 Secondary data

#### 3.3.1.1 Air service operational data

To assess SATENA's current air service provision (Objective 1), a range of operational variables was extracted from publicly available databases. The primary sources were:

- Aerocivil (Colombian Civil Aviation Authority): Monthly operational reports, load factors, and airport activity.
- OAG: Schedules, frequencies, and aircraft types.
- SATENA: Direct information about routes, fleet, and timetables.

Table 3-1 summarises the operational data collected and their respective sources:

**Table 3-1.** Operational data for the analysis.

| Variable                     | Source            |
|------------------------------|-------------------|
| Route origin and destination | OAG, SATENA       |
| Start year of operation      | SATENA, Aerocivil |
| Weekly frequency             | OAG, SATENA       |
| Days and times of operation  | SATENA            |
| Aircraft type                | OAG, SATENA       |
| Seat capacity                | SATENA            |
| Load factor                  | Aerocivil         |

These variables provide a foundation for evaluating the accessibility, reliability, and performance of each subsidised air route.

#### 3.3.1.2 Community needs data

To analyse community characteristics and access connectivity needs (Objective 2), a set of demographic, socioeconomic, and geographic indicators was collected. Sources include:

- DANE (National Administrative Department of Statistics)
- World Bank Open Data
- ArcGIS

Table 3-2 shows all the variables collected for both origin and destination points of each case study route.

**Table 3-2.** Socioeconomic data for the analysis.

| Variable                                   | Source             |
|--------------------------------------------|--------------------|
| Total population (catchment area)          | ArcGIS             |
| Population aged 0–14 and 60+               | ArcGIS             |
| Purchasing power per capita                | World Bank, ArcGIS |
| Multidimensional Poverty Index (MPI)       | DANE               |
| % Population <2 km from a transitable road | DANE               |
| 3-hour driving catchment area (sq. km)     | ArcGIS             |

A 3-hour drive catchment area was calculated to estimate the population with reasonable access to each airport, and therefore the potential user base of the air route under study. This approach accounts for Colombia's complex geography, where reaching an airport can be difficult due to limited road infrastructure and natural barriers (OECD, 2022).

The Multidimensional Poverty Index (MPI) is especially relevant, as it reflects multiple deprivations in health, education, and living standards, offering a better understanding of vulnerability across Colombian regions than income alone (DANE, 2025).

### **3.3.2 Primary data**

Primary data were collected through online questionnaires designed to gather perspectives from both the supply and demand sides of subsidised air services. These tools support Objectives 2, 3 and 5. Two separate questionnaires were developed using Qualtrics (2025) to collect primary data from key stakeholders and users of SATENA's services. Each was designed to support the evaluation and development of the service classification framework and to incorporate user perspectives on the adequacy of current air services. To ensure accessibility for Colombian respondents, the questionnaires were available in both Spanish and English, recognising that many participants may not speak English fluently. They were distributed via email and LinkedIn.

#### **3.3.2.1 Questionnaire 1: Industry stakeholders**

This questionnaire targeted key actors involved in subsidised air transport in Colombia, including representatives from the government agency Aerocivil,

SATENA, UPIT, aviation professionals, and academics familiar with regional air connectivity. It consisted of three main sections:

1. **Variable weighting:** Respondents were asked to rate the importance of different service level variables from 1 to 5.
2. **Pairwise comparisons:** Participants completed pairwise comparisons of variables, selecting which one they considered more important in each pair and indicating the strength of preference on a scale from 1 to 9. This exercise enabled the application of the Analytic Hierarchy Process (AHP) as part of a Multi-Criteria Decision-Analysis (MCDA) approach.
3. **Route familiarity and benchmarks:** Respondents indicated their familiarity with the selected case study routes. For each known route, they provided professional opinions on service expectations, including the minimum number of weekly flights, acceptable departure times, and whether same-day return should be feasible.

Additional background questions about the respondent's organisation and role were also included. A complete version of the questionnaire, including all questions and answer formats, is provided in Appendix B.2.

### 3.3.2.2 Questionnaire 2: SATENA users

The second questionnaire was directed at SATENA passengers, particularly individuals residing in or frequently travelling to and from the communities covered by the case study routes. It aimed to understand the user experience and perceived adequacy of the services.

The questionnaire began with background questions about the respondent's travel frequency and main purpose for flying with SATENA. It then included the following components:

- **Route familiarity:** Participants indicated which of the five case study routes they had flown.
- **Service evaluation:** For each route the respondent had experience with, they were asked to assess key service dimensions, including the number of weekly flights, flight schedule, reliability, affordability, and whether the service allowed for same-day return.

- **Accessibility:** A dedicated section explored how users reached the airport at their destination, the duration of their journey from home, their alternatives in the absence of air transport, and their willingness to accept routes with intermediate stops.

A full copy of the questionnaire, including all questions and response options, is provided in Appendix B.1.

### **3.4 Analytical methods**

This section defines the analytical techniques used to achieve each of the five research objectives. The methods combine quantitative and qualitative approaches and are structured according to the phased methodology described earlier. Each objective is addressed through a specific set of tools, relying on both secondary and primary data sources.

#### **3.4.1 Objective 1: Evaluation of air services**

Given Colombia's size, geographic diversity, and regional disparities in development and infrastructure (Duque et al., 2023), a nationwide analysis of subsidised air services was beyond the scope of this research. Instead, a case study approach was adopted, focusing on five selected routes. These routes were chosen to reflect the variety of contexts present across Colombia, including differences in geography, socioeconomic conditions, and levels of connectivity.

To identify the most relevant routes, an initial screening process was conducted using secondary data from Aerocivil, SATENA, and DANE. This analysis focused on regions with significant indicators of isolation and vulnerability, such as high poverty rates, limited road access, or low air service frequency. The five selected routes showcase the challenges faced in providing equitable air connectivity and will be detailed further in the results section.

The evaluation of these routes was carried out using operational data obtained from Aerocivil, SATENA, and OAG. A range of service indicators, detailed in Table 3-1, were analysed to assess the adequacy and performance of each route. These included metrics related to capacity, schedule design, aircraft type, and

load factors (where available). Additional qualitative features such as weekday coverage and route maturity were also considered to evaluate how effectively each route meets the connectivity needs of its region.

### **3.4.2 Objective 2: Community needs assessment**

The second objective addressed the transport needs of communities located at the origin and destination of the selected routes. To achieve this, indicators such as population, poverty levels, access to road infrastructure, and geographic isolation were collected and analysed. The methodological approach follows similar studies in rural and regional accessibility, such as those by Deboosere and El-Geneidy (2018) and Leão e Silva et al. (2022), which demonstrate the usefulness of combining demographic, spatial, and economic indicators to assess connectivity needs.

To estimate population accessibility, three-hour driving time catchment areas were calculated around each airport using GIS-based tools (ArcGIS, 2025). This technique allows the identification of potential users who could realistically access the airport, accounting for Colombia's complex geography. The findings provide the necessary foundation to compare service levels with community needs.

### **3.4.3 Objectives 3 and 4: Service level framework development**

To develop a structured framework for assessing the quality of subsidised air services, this research first identified a core set of service variables:

- Frequency of flights (per week)
- Schedule (time of day)
- Day-return possibility
- Total flight time
- Aircraft type (regional jet vs turboprop)

This selection was informed by academic literature (Adler et al., 2025; Alkhatib & Migdadi, 2018; Bråthen & Eriksen, 2018), operational criteria used by airlines and regulators (European Commission, 2024), and initial stakeholder feedback. In addition, factors particularly relevant to communities in Colombia were

considered, incorporating what SATENA users identify as most important when defining service levels.

These variables were evaluated using a two-step quantitative approach. First, a Weighted Sum Model (WSM) was applied based on the variable importance ratings collected through stakeholder questionnaire. This allowed for the generation of preliminary weights reflecting the perceived impact of each variable on service quality.

Second, a pairwise comparison method using the Analytic Hierarchy Process (AHP) was employed to cross-validate the relative importance of these variables. Respondents compared service aspects in pairs using a Saaty scale from 1 (equal importance) to 9 (extreme importance), resulting in a matrix that produced priority vectors to refine the variable weights (Saaty, 1987).

The outputs of WSM and AHP were then combined to generate final weighted scores for each service variable (Konidari & Mavrakis, 2007; Saaty, 1987). These weights serve as a foundation for a flexible service level framework, designed to classify services into performance tiers (basic, adequate, optimal).

However, since regional conditions vary significantly across Colombia, this framework is not intended to impose fixed benchmarks. Instead, it functions as a comparative tool: service levels are assessed relative to each region's specific needs and constraints. The actual classification will be applied per route in the next stage of the analysis.

A graphical summary of this process is provided in Figure 3-2.

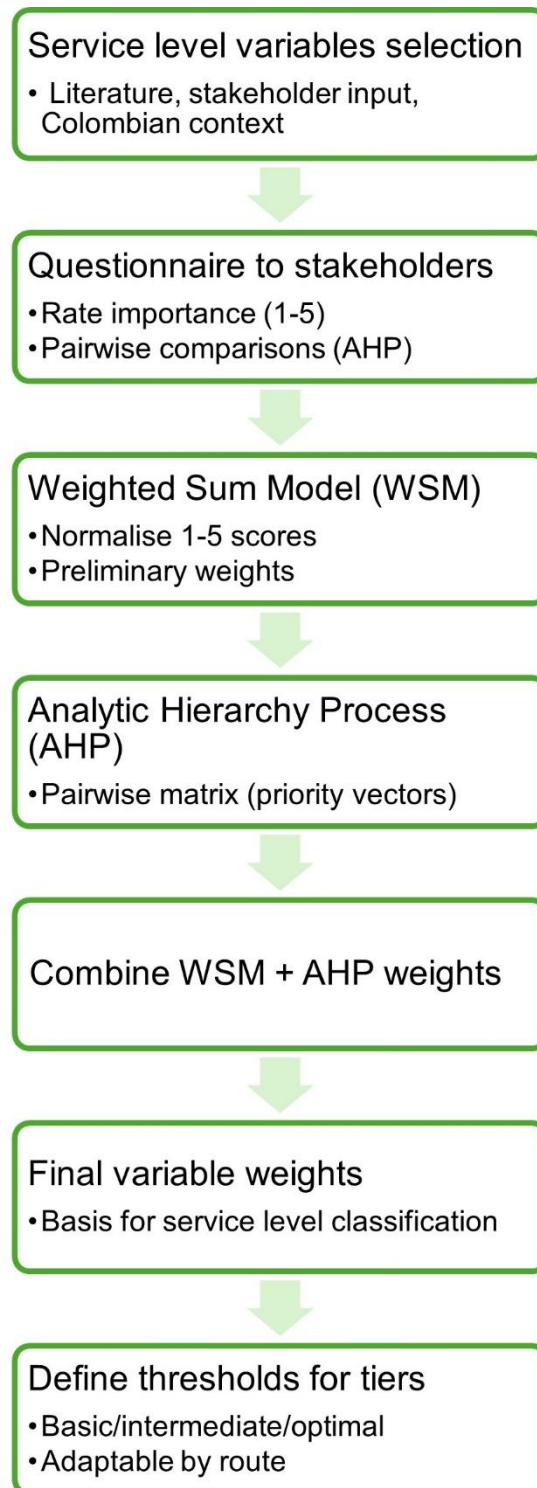


**Figure 3-2.** Service classification methodology.

#### **3.4.4 Objective 5: Application of framework**

The final objective of the research consists in applying the service level framework to the five selected case study routes in Colombia. Using the weighted service variables established through stakeholder input and analytical methods, the goal is to assess the current quality of subsidised air services and determine how well they meet regional needs.

For each route, operational performance will be evaluated against the service expectations derived from questionnaire responses. These include thresholds for what stakeholders and SATENA users consider minimum or optimal in terms of frequency, schedule convenience, accessibility, and other relevant factors. The actual service characteristics of each route will be scored accordingly, using the final weights obtained from the WSM and the AHP.

By aggregating these weighted scores, each route will be classified into one of three service levels: basic, adequate, or optimal. This classification shows that service adequacy may vary depending on geographic isolation, population, and local connectivity needs (Cattaneo et al., 2022).

This case study application validates the framework's adaptability and offers insights for improving air service provision in underserved Colombian regions.

### **3.5 Ethical considerations**

All research activities involving human participants were conducted in accordance with ethical guidelines to ensure informed consent, confidentiality, and voluntary participation. Participants were provided with clear information about the purpose of the study and their rights, and consent was obtained prior to participation. Moreover, data was anonymised and securely stored.

As shown in Appendix A, ethical approval was granted for this study on 26<sup>th</sup> June 2025 (Reference: CURES/25810/2025; Project ID: 29027) by the Cranfield University Research Ethics System (CURES).

### **3.6 Summary**

This chapter presented the methods used to evaluate subsidised air services in Colombia, combining secondary data analysis with stakeholder input through questionnaires. A structured framework was developed to classify service levels, later applied to five case study routes. The next chapter presents the findings, integrating both quantitative assessments and user perspectives.

## **4 Results and discussion**

### **4.1 Introduction**

This chapter presents the results of the analysis conducted to evaluate and classify subsidised air services in Colombia. It begins by introducing the five selected routes and justifying their relevance. This is followed by an assessment of current service performance and community needs. The findings from the questionnaires are then analysed to identify key variables influencing service quality. These variables are used to develop a classification framework which is subsequently applied to the selected routes. The chapter concludes with a discussion of the main findings and their implications for regional connectivity policy.

### **4.2 Selection of case study routes**

To ensure a representative analysis, five subsidised air routes in Colombia were selected based on a set of strategic criteria. The primary aim was to include routes that reflect the diversity of Colombia's remote air transport network, balancing geographical, operational, and social considerations.

All selected routes are operated exclusively by SATENA, the state-owned airline responsible for serving remote regions. This criterion was essential to focus the study on the public service dimension of subsidised air transport. Additionally, routes classified as "rutas sociales", meaning those that play a critical role in connecting isolated communities, were prioritised.

To capture a broad range of service dynamics, routes were chosen to include both tourism-oriented destinations and those that are vital for community access to essential services. Furthermore, a mix of mature and recently introduced routes was included to allow comparative analysis of service evolution over time. Routes were also selected from different departments, ensuring geographical diversity across Colombia's vast and varied territory.

As seen in Figure 4-1, the final selection comprises:

- Bogotá – Mitú: A long-standing route essential for connectivity in the Vaupés region.
- San Andrés – Providencia (Islands): A key link between two island territories with tourism and socioeconomic relevance.
- Medellín – Mompox: A route with cultural and emerging tourism value, recently reintroduced.
- Cali – Timbiquí: A critical route for Afro-Colombian communities on the Pacific coast.
- Leticia – Tarapacá: A short-haul route connecting small Amazonian settlements with the departmental capital.

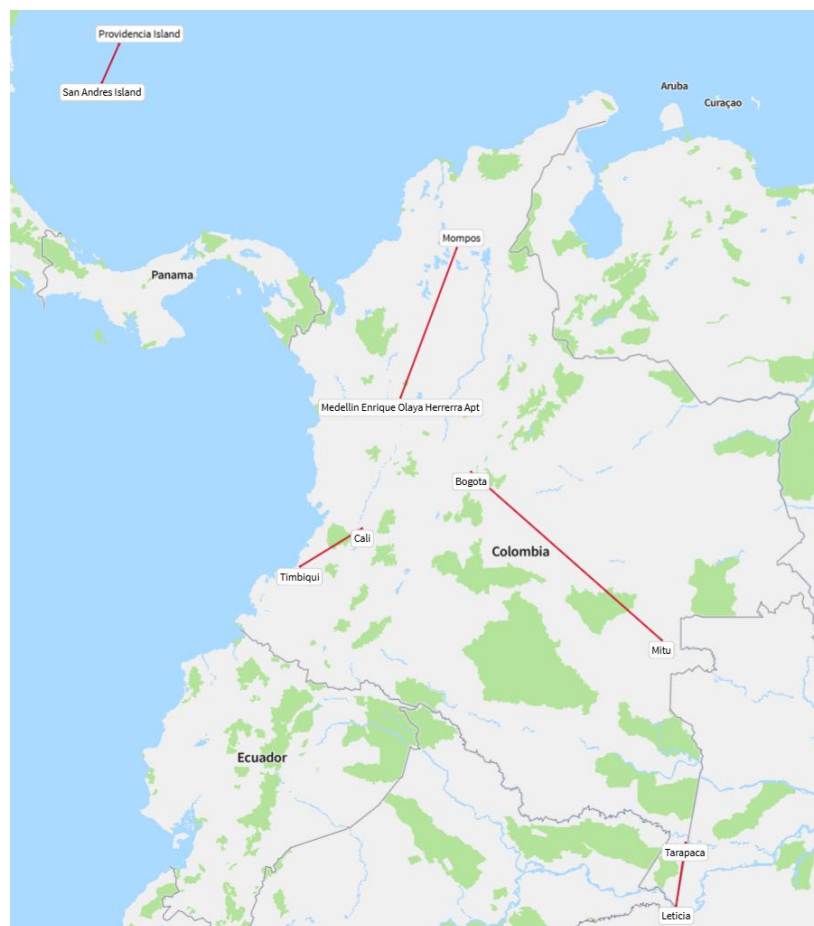


**Figure 4-1.** Case study routes in Colombia (OAG, 2025a).

This selection provides a balanced sample for assessing service levels and community impact across different contexts.

### 4.3 Current service assessment and community needs

This section evaluates each selected route in terms of current air service provision and the corresponding socio-economic needs of the communities they serve. The analysis considers key operational characteristics such as frequency, schedules, aircraft type, and load factors, alongside demographic and geographic data to assess the adequacy of service.

#### 4.3.1 Bogotá – Mitú

The Bogotá – Mitú route is one of the most consolidated among the selected case studies. In operation for over ten years, it is served by a 50-seat Embraer RJ145 aircraft (OAG, 2025b). Flights are offered six days per week, from Monday to Saturday (SATENA, 2025), with consistent outbound and return schedule. Weekly frequencies and regular seat availability indicate a stable and mature service pattern. Detailed operational characteristics of the route are summarised in Table 4-1.

**Table 4-1.** Operational characteristics of the Bogotá – Mitú route.

| Parameter          | Bogotá–Mitú (BOG–MVP) |
|--------------------|-----------------------|
| Route maturity     | More than 10 years    |
| Aircraft type      | Embraer RJ145         |
| Seat capacity      | 50 pax                |
| Days of operation  | Monday to Saturday    |
| Weekly frequency   | 6                     |
| Schedules          |                       |
| BOG–MVP            | Mon 13:10–14:35       |
|                    | Tue 08:48–10:13       |
|                    | Wed 10:20–11:45       |
|                    | Thu 08:25–09:50       |
|                    | Fri 11:05–12:30       |
|                    | Sat 14:45–16:10       |
| MVP–BOG            | Mon 15:22–16:40       |
|                    | Tue 10:37–11:57       |
|                    | Wed 12:27–13:45       |
|                    | Thu 10:39–11:57       |
|                    | Fri 12:57–14:15       |
|                    | Sat 16:55–18:13       |
| Load factor (2025) | 88%                   |

Figure 4-2 presents the 3-hour drive catchment areas for Bogotá and Mitú (ArcGIS, 2025). While Bogotá’s area covers over 10,000 km<sup>2</sup> and includes nearly 3.9 million people, Mitú’s catchment is extremely limited, serving a population of 17,557. The map reveals the central town as the only populated nucleus, connected by a single road segment, the only transitable route in the region. This reflects the lack of road connectivity in the Vaupés department. In practice, air travel is the only option to access essential services or travel beyond the region.

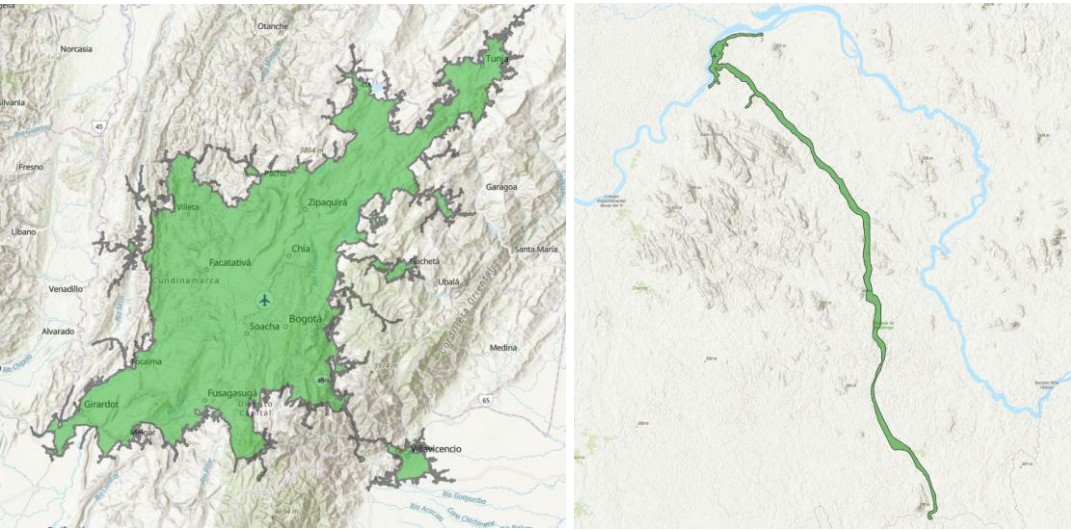


**Figure 4-2.** 3-hour drive catchment areas for Bogotá (left) and Mitú (right) (ArcGIS, 2025).

Table 4-2 also compares key socioeconomic indicators. Mitú faces severe challenges: 45% of its population is under 15 or over 60, the Multidimensional Poverty Index (MPI) is 74.8% (DANE, 2025), and the purchasing power per capita is nearly half that of the capital. The lack of available data on road proximity is consistent with known infrastructure limitations and the very small catchment area.

**Table 4-2.** Socioeconomic indicators in Bogotá and Mitú.

| Indicator                                  | Bogotá     | Mitú       |
|--------------------------------------------|------------|------------|
| Total population (catchment area)          | 3,869,087  | 17,557     |
| Population aged 0–14                       | 812,804    | 6,855      |
| Population aged 60+                        | 543,739    | 1,123      |
| Purchasing power per capita (COP)          | 21,737,909 | 11,481,533 |
| Multidimensional Poverty Index (MPI)       | 9%         | 74.8%      |
| % Population <2 km from a transitable road | 88.87%     | -          |
| 3-hour drive catchment size (sq. km)       | 10,219     | 28.16      |

Given these conditions, the Bogotá – Mitú service appears appropriate and necessary. Its frequency, seat capacity, and reliability help mitigate the region's extreme isolation. However, the community's high dependency and poverty levels highlight the importance of maintaining affordable and consistent air access as a public service rather than a purely commercial route.

#### 4.3.2 San Andrés – Providencia

The San Andrés – Providencia route is a long-established and intensively operated connection, served by SATENA using a 48-seat ATR 42 aircraft (OAG, 2025b). The route has been in operation for over a decade and maintains daily flights in both directions, with up to four round trips. The 2025 load factor of 79.3% reflects strong and consistent demand (Aerocivil, 2025). A summary of the route's operational characteristics is presented in Table 4-3.

**Table 4-3.** Operational characteristics of the San Andrés – Providencia route.

| Parameter          | San Andrés–Providencia (ADZ–PVA)                                                                                           |
|--------------------|----------------------------------------------------------------------------------------------------------------------------|
| Route maturity     | More than 10 years                                                                                                         |
| Aircraft type      | ATR 42                                                                                                                     |
| Seat capacity      | 48 pax                                                                                                                     |
| Days of operation  | Every day                                                                                                                  |
| Weekly frequency   | 24                                                                                                                         |
| Schedules          |                                                                                                                            |
| ADZ–PVA            | Mon, Wed, Fri: 7:05–7:42, 9:30–10:07, 11:40–12:17, 15:10–15:47<br>Tue, Thu, Sat, Sun: 7:05–7:42, 11:40–12:17, 15:10–15:47  |
| PVA–ADZ            | Mon, Wed, Fri: 8:20–8:56, 10:30–11:06, 12:40–13:16, 16:20–16:56<br>Tue, Thu, Sat, Sun: 8:20–8:56, 12:40–13:16, 16:20–16:56 |
| Load factor (2025) | 79.3%                                                                                                                      |

Figure 4-3 displays the 3-h drive catchment areas for San Andrés and Providencia. As expected, given their island nature, the catchment areas are confined to the islands themselves, with 28 km<sup>2</sup> for San Andrés and 19 km<sup>2</sup> for Providencia (Table 4-4). Both islands exhibit complete road accessibility, with 100% of the population living within 2 km of a transitable road (DANE, 2021). However, the geographic isolation limits connectivity options. The only alternative to air travel is a catamaran service, which is less reliable due to weather conditions and long travel times (Rome2Rio, 2025).

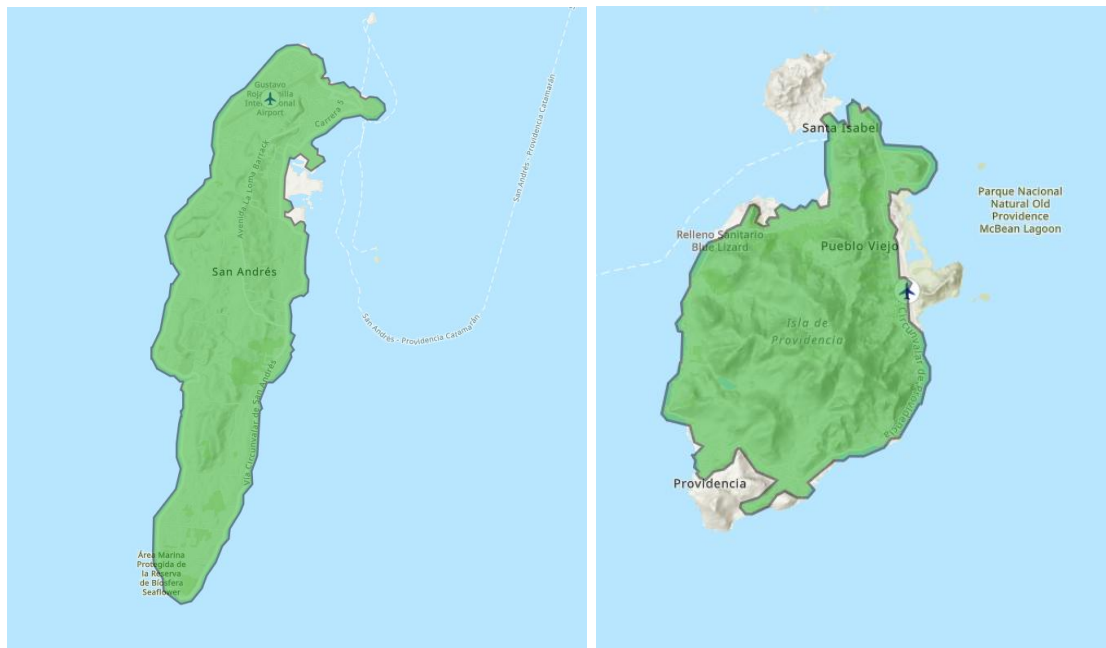


**Figure 4-3.** 3-hour drive catchment areas for San Andrés (left) and Providencia (right) (ArcGIS, 2025).

Socioeconomic indicators suggest differing but complementary needs. San Andrés has a population of nearly 55,000, while Providencia hosts just over 5,500 residents. Both communities show a notable proportion of young and elderly populations, indicating dependence on frequent and accessible travel. Purchasing power is higher than in other case studies, and MPI values are relatively low, indicating better socioeconomic conditions. The high service frequency and load factor suggest that current services are aligned with community needs, although future resilience will depend on maintaining regularity and affordability.

**Table 4-4.** Socioeconomic indicators in San Andrés and Providencia.

| Indicator                                  | San Andrés | Providencia |
|--------------------------------------------|------------|-------------|
| Total population (catchment area)          | 54,879.00  | 5,534.00    |
| Population aged 0–14                       | 11,460     | 1,233       |
| Population aged 60+                        | 9,267      | 989         |
| Purchasing power per capita (COP)          | 25,191,528 | 21,633,348  |
| Multidimensional Poverty Index (MPI)       | 16.8%      | 13.7%       |
| % Population <2 km from a transitable road | 100%       | 100%        |
| 3-hour drive catchment size (sq. km)       | 28.18      | 18.74       |

### 4.3.3 Medellín – Mompox

The Medellín – Mompox route is one of the three launched routes in 2024 selected for this study. Operated by a 19-seat Beechcraft 1900D, it offers three weekly flights (see Table 4-5). Despite being in its early stages, the service has already achieved a promising load factor of 71% (Aerocivil, 2025), suggesting strong relevance of the communities it connects. Though frequency remains limited, the route fills a critical gap in connectivity for Mompox, a town with historical, cultural, and emerging tourism significance but limited transport options (Procolombia, 2024).

**Table 4-5.** Operational characteristics of the Medellín – Mompox route.

| Parameter          | Medellín–Mompox (EOH–MMP)                   |
|--------------------|---------------------------------------------|
| Route maturity     | Started in 2024                             |
| Aircraft type      | Beechcraft 1900D Airliner                   |
| Seat capacity      | 19 pax                                      |
| Days of operation  | Monday, Wednesday, and Friday               |
| Weekly frequency   | 3                                           |
| Schedules          |                                             |
| EOH–MMP            | Mon and Fri: 7:30–8:37<br>Wed: 14:00–15:07  |
| MMP–EOH            | Mon and Fri: 9:00–10:00<br>Wed: 15:30–16:30 |
| Load factor (2025) | 71.3%                                       |

Figure 4-4 presents the 3-hour drive catchment areas for Medellín and Mompox. Medellín’s catchment spans nearly 10,000 km<sup>2</sup> and includes over five million people, underscoring its role as a major urban and economic centre (Cámara de

Comercio de Medellín, 2024). Mompox's catchment, while larger in area, is far less populated, with approximately 587,000 residents. According to regional data (DANE, 2021), only 29% of the population in the Bolívar department, where Mompox is located, lives within 2 km of a transitable road, highlighting major limitations in ground access throughout the area. This contrasts with the 73% in Antioquia, where Medellín is located, which has a more developed road network.

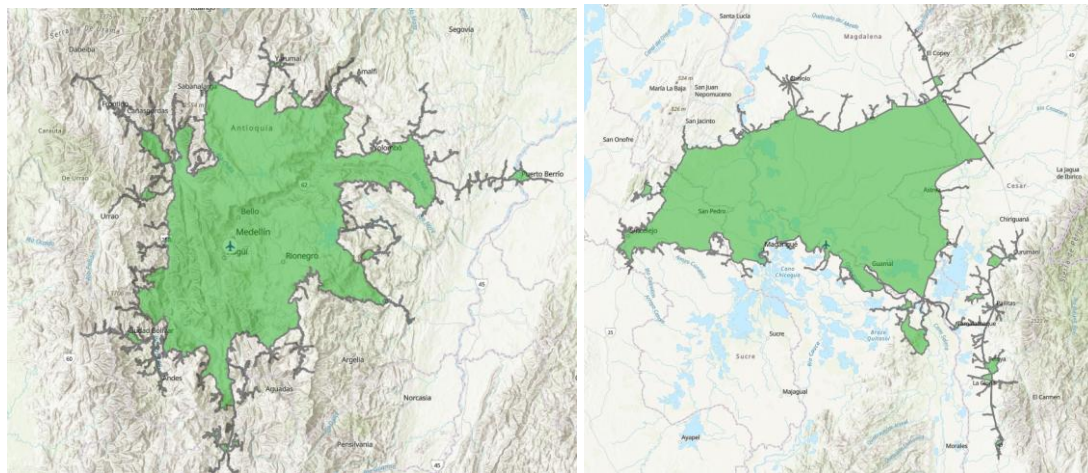


**Figure 4-4.** 3-hour drive catchment areas for Medellín (left) and Mompox (right) (ArcGIS, 2025).

The socioeconomic contrast between the two regions is notable. Medellín reports low MPI of 12.8% and a high purchasing power per capita. Mompox, in contrast, shows a high MPI of 49% and lower income indicators. These differences, combined with the significant shares of youth and elderly populations, underline the importance of reliable air services to support inclusion, access to services, and economic opportunities.

**Table 4-6.** Socioeconomic indicators in Medellín and Mompox.

| Indicator                                  | Medellín   | Mompox     |
|--------------------------------------------|------------|------------|
| Total population (catchment area)          | 5,084,702  | 587,430    |
| Population aged 0–14                       | 881,071    | 161,662    |
| Population aged 60+                        | 883,473    | 80,636     |
| Purchasing power per capita (COP)          | 25,582,945 | 10,386,044 |
| Multidimensional Poverty Index (MPI)       | 12.8%      | 49.1%      |
| % Population <2 km from a transitable road | 73.26%     | 28.98%     |
| 3-hour drive catchment size (sq. km)       | 9,862      | 11,721     |

4.3.4 Cali – Timbiquí

The Cali – Timbiquí air route is another new service launched by SATENA in 2024 to enhance regional connectivity (Aerocivil, 2023). Operated by a 19-seat Beechcraft 1900D, it currently runs three times per week, maintaining a consistent outbound morning schedule from Cali and variable return times from Timbiquí, as seen in Table 4-7. Despite its recent implementation, the service has achieved a high load factor of 83.3%, suggesting strong demand and utilisation (Aerocivil, 2025).

Table 4-7. Operational characteristics of the Cali – Timbiquí route.

| Parameter          | Cali–Timbiquí (CLO–TBD)       |
|--------------------|-------------------------------|
| Route maturity     | Started in 2024               |
| Aircraft type      | Beechcraft 1900D Airliner     |
| Seat capacity      | 19 pax                        |
| Days of operation  | Monday, Wednesday, and Friday |
| Weekly frequency   | 3                             |
| Schedules          |                               |
| CLO-TBD            | 7:00–7:50 (all days)          |
| TBD–CLO            | Mon: 11:55–12:43              |
|                    | Wed and Fri: 14:20–15:08      |
| Load factor (2025) | 83.3%                         |

Figure 4-5 displays the 3-hour drive catchment areas for Cali and Timbiquí. While Cali’s area covers around 10,000 km<sup>2</sup> and serves 4.7 million people, Timbiquí’s accessible area is drastically limited, covering less than 2 km<sup>2</sup>. This underscores the severe limitations of local ground infrastructure, meaning that air transport is often the only feasible way to travel to and from the region.

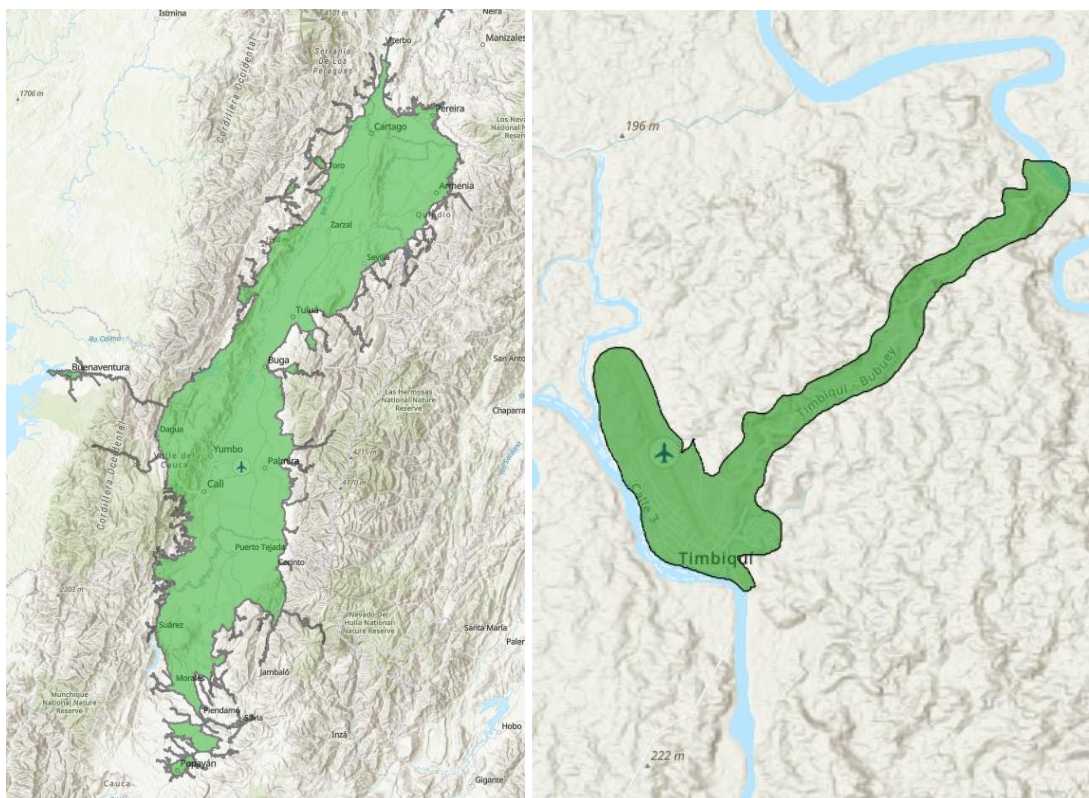


**Figure 4-5.** 3-hour drive catchment areas for Cali (left) and Timbiquí (right) (ArcGIS, 2025).

Socioeconomic data also highlights significant disparities between the two ends of the route. Timbiquí has a high proportion of young residents, a low purchasing power per capita (COP 10.6 million), and an alarming MPI of 72.4%. These indicators point to strong mobility needs, particularly for accessing health, education, and public services not available locally.

**Table 4-8.** Socioeconomic indicators in Cali and Timbiquí.

| Indicator                                  | Cali       | Timbiquí   |
|--------------------------------------------|------------|------------|
| Total population (catchment area)          | 4,699,387  | 8,784      |
| Population aged 0–14                       | 923,001    | 3,078      |
| Population aged 60+                        | 833,702    | 782        |
| Purchasing power per capita (COP)          | 22,957,253 | 10,576,453 |
| Multidimensional Poverty Index (MPI)       | 11.9%      | 72.4%      |
| % Population <2 km from a transitable road | 77.22%     | 57.73%     |
| 3-hour drive catchment size (sq. km)       | 9,970      | 1.97       |

Overall, the high load factor and socioeconomic indicators suggest that the current air service is well-justified. While the limited frequency may not meet all mobility needs, the route clearly addresses a critical gap in access for an underserved community, and its continued operation will be essential for regional inclusion.

#### 4.3.5 Leticia – Tarapacá

The Leticia – Tarapacá route is the third of the newly launched air services studied in this research, having commenced operations in 2024 (OAG, 2025b). It is served by a 19-seat Beechcraft 1900D, operating twice weekly on Tuesdays and Fridays (Table 4-9). As of July 2025, no load factor data is available from Aerocivil, possibly due to the route’s recent launch and low reporting volume.

**Table 4-9.** Operational characteristics of the Leticia – Tarapacá route.

| Parameter          | Leticia–Tarapacá (LET–TCD)           |
|--------------------|--------------------------------------|
| Route maturity     | Started in 2024                      |
| Aircraft type      | Beechcraft 1900D Airliner            |
| Seat capacity      | 19 pax                               |
| Days of operation  | Tuesday and Friday                   |
| Weekly frequency   | 2                                    |
| Schedules          |                                      |
| LET-TCD            | 9:00–9:45 (both days)                |
| TCD-LET            | Tue: 10:05–10:50<br>Fri: 10:25–11:10 |
| Load factor (2025) | -                                    |

Figure 4-6 displays the 3-hour catchment areas around Leticia and Tarapacá airports. The spatial coverage is extremely limited, particularly around Tarapacá, where the catchment spans less than 1 km<sup>2</sup>. Both areas show almost total absence of road connectivity, with just 1% of the population residing within 2 km of a transitable road in the Amazonas department. The catchment maps confirm that these communities are effectively disconnected from the national road network and rely exclusively on river or air transport for mobility and access to services.

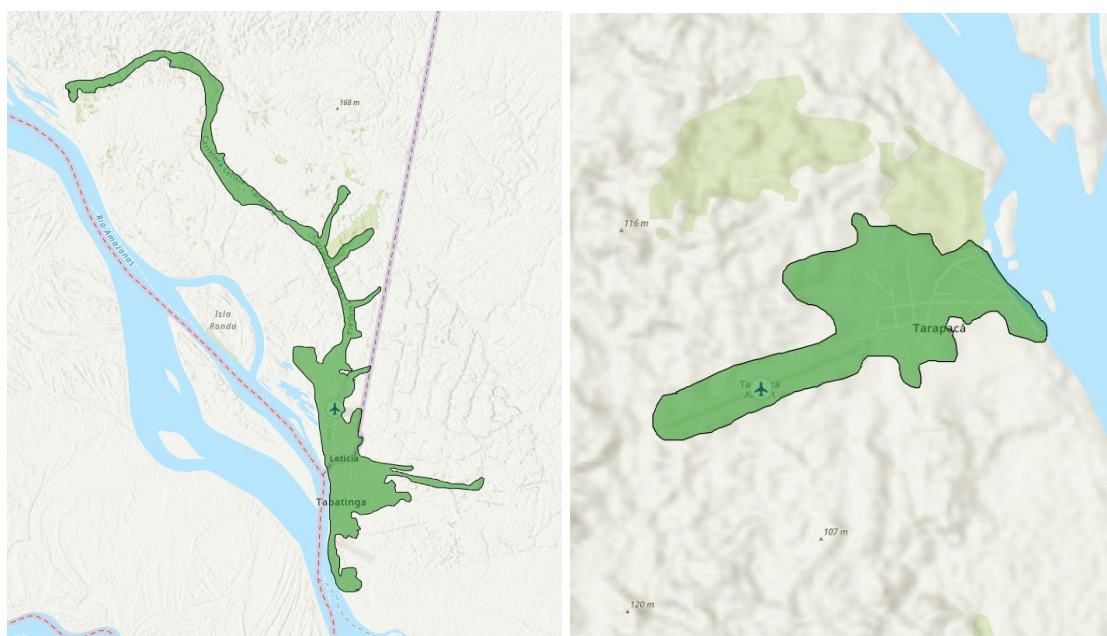


**Figure 4-6.** 3-hour drive catchment areas for Leticia (left) and Tarapacá (right) (ArcGIS, 2025).

Socioeconomic indicators (Table 4-10) show a population of just over 2,200 in the Tarapacá catchment, marked by a high proportion of children (39%), and a MPI of 80%, the highest among all case studies. Purchasing power per capita is just COP 7 million, far below the national average (World Bank Open Data, 2024). Leticia, while presenting stronger indicators, still reflects significant needs, with 48.4% of the population in multidimensional poverty.

**Table 4-10.** Socioeconomic indicators in Leticia and Tarapacá.

| Indicator                                  | Leticia    | Tarapacá  |
|--------------------------------------------|------------|-----------|
| Total population (catchment area)          | 46,341     | 2,261     |
| Population aged 0–14                       | 14,486     | 872       |
| Population aged 60+                        | 3,470      | 179       |
| Purchasing power per capita (COP)          | 14,994,338 | 7,077,430 |
| Multidimensional Poverty Index (MPI)       | 48.4%      | 80%       |
| % Population <2 km from a transitable road | 1%         | 1%        |
| Catchment size (sq. km)                    | 38.71      | 0.82      |

In this context, air services between Leticia and Tarapacá are not only essential but the only viable means of ensuring connectivity. The current twice-weekly

frequency represents a critical lifeline, though future adjustments may be necessary as community needs and mobility patterns evolve.

In summary, the five selected routes demonstrate a wide variation in terms of maturity, service frequency, and socioeconomic conditions within their respective catchment areas. These disparities highlight the complex relationship between air connectivity and regional development. To complement this quantitative and contextual analysis, the next section will present the perspectives of actual users of these air services.

## **4.4 Stakeholder and community insights**

This section presents insights from industry stakeholders and community members gathered through two targeted questionnaires.

### **4.4.1 SATENA users questionnaire**

This questionnaire was open for 20 days, from the 1<sup>st</sup> to the 21<sup>st</sup> of July 2025, and received a total of 34 responses. While not all participants completed every question, all submitted responses have been considered valuable and are included in the analysis where applicable. The aim of the questionnaire was to gather insights from users of SATENA regarding travel patterns, perceptions of service quality, and experiences on specific routes, with a focus on remote destinations.

#### **4.4.1.1 Respondent profile**

To understand the background and travel behaviour of respondents, two initial questions addressed the main purpose of travel and frequency of air travel with SATENA. Figure 4-7 indicates that the most common reason for flying with SATENA is work-related travel (13 respondents), followed by tourism (10) and family visits (3). This suggests that the airline plays a role in connecting remote communities for both economic and personal purposes.

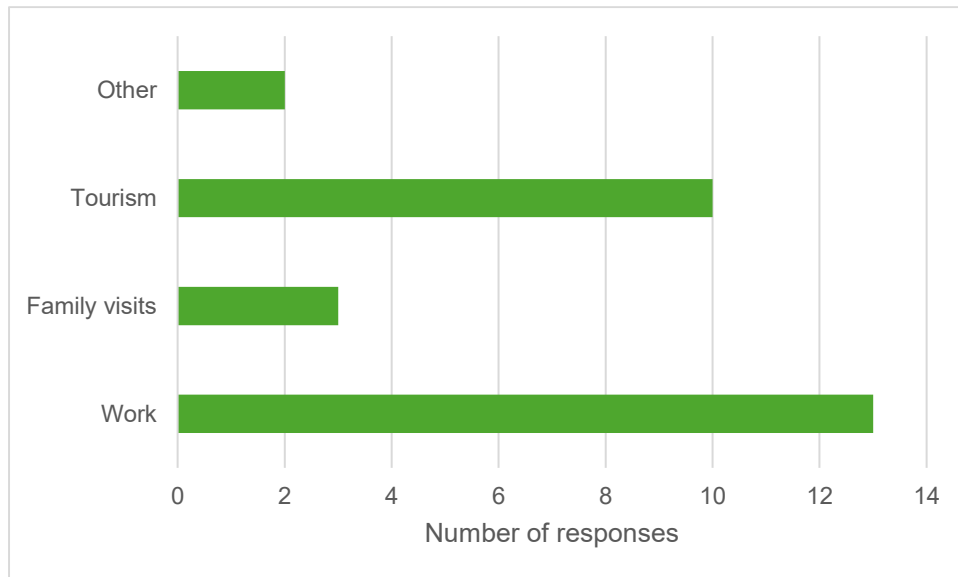


**Figure 4-7.** Main reason for travelling with SATENA.

As shown in Figure 4-8, most respondents indicated they fly with SATENA once per year or less (52%) or a few times per year (28%). Only a few are more frequent flyers, with 8% travelling monthly and 4% weekly. These results reflect SATENA's profile as a carrier serving occasional but essential travel needs, rather than frequent business commuting typical of high-density corridors.

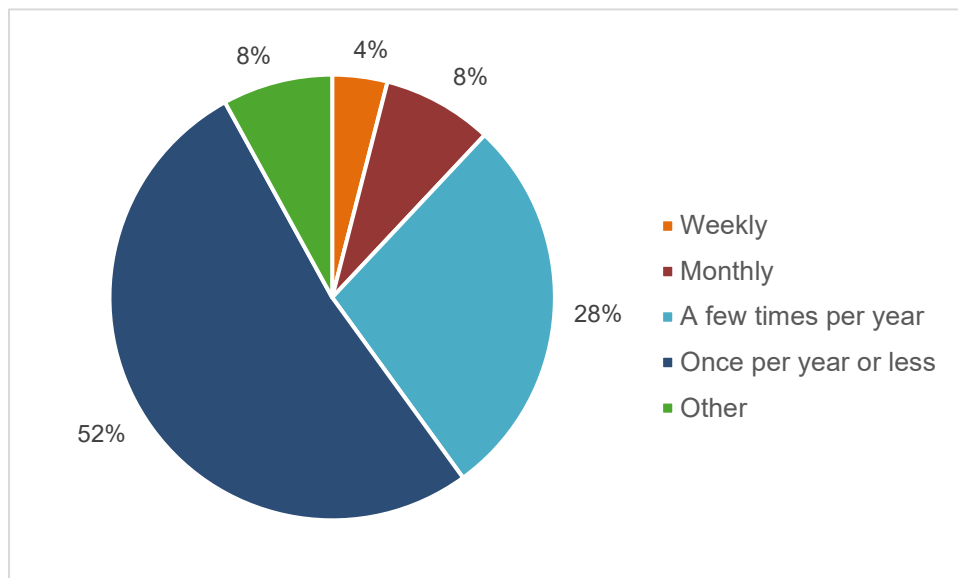


**Figure 4-8.** Frequency of air travel with SATENA.

#### 4.4.1.2 Route familiarity

Respondents were then asked to indicate which SATENA routes they had flown (see Figure 4-9). Of the five case study routes selected for this research, San Andrés – Providencia was the most flown, with 11 responses, followed by Bogotá – Mitú (3), Medellín – Mompox (2), and Cali – Timbiquí (1). No respondents had travelled on Leticia – Tarapacá, possibly due to its lower demand or more specialised nature.

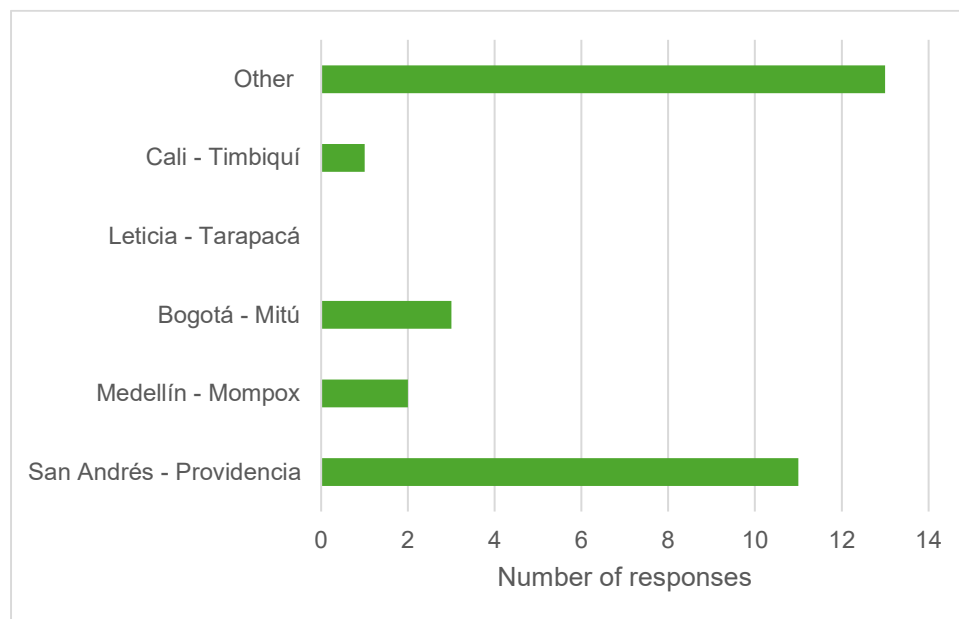


**Figure 4-9.** Routes flown by SATENA users.

A significant number (13 responses) selected “Other”, listing more common routes such as Bogotá – Medellín, Medellín – Apartadó, and Bogotá – Cali. These are high-demand routes served by multiple airlines (OAG, 2025b) and fall outside the scope of this research, which focuses on remote destinations served exclusively by SATENA.

This route familiarity question also serves to guide the depth of route-specific analysis in subsequent sections, where only the case study routes with enough feedback (primarily Bogotá – Mitú and San Andrés – Providencia) will be explored in more detail.

#### 4.4.1.3 Service perception

This subsection presents user perceptions of service quality on the case study routes. While response numbers vary, the insights provide useful indications of how SATENA's services are experienced by passengers.

Although only three responses were received for the **Bogotá – Mitú** route, they provide a consistent view of the service and have been included in the analysis. Two respondents considered the number of weekly flights to be adequate, while one believed there were too few. All three participants found the flight schedule acceptable, and the reliability of the service was rated positively, with one person stating flights are always on time and two indicating they are on time most of the time.

In terms of affordability, two respondents found the fares somewhat affordable, while one considered them too expensive. When asked about same-day travel, responses were mixed: one respondent always travels and returns on the same day, another sometimes does, and one never does, highlighting differing travel patterns depending on individual needs.

The **San Andrés – Providencia** route received the highest number of responses, with eleven participants contributing to the analysis. Most respondents felt the number of flights offered per week was adequate (Figure 4-10), while two thought there were too few. The flight schedule was widely regarded as acceptable (9 responses), with one respondent describing it as very convenient. Service reliability showed a broader range of perceptions: 18% said flights are always on time, 46% said most of the time, and the remaining indicated less consistent punctuality.

Opinions on airfare affordability were more divided, where six respondents found prices too expensive, while five considered them somewhat affordable. As for travel habits, most users stated that they never return on the same day, suggesting overnight or extended stays are common, while 18% said they return the same day, either always or sometimes (Figure 4-13).

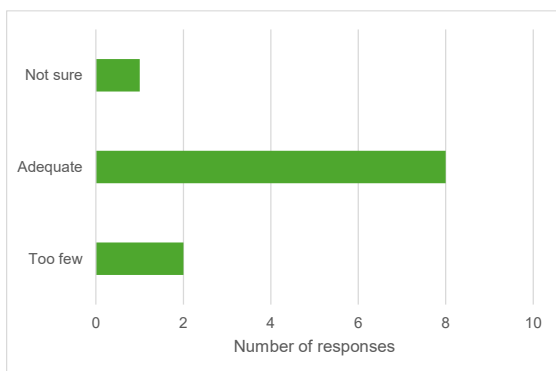


**Figure 4-10.** Adequacy of weekly flight frequencies.

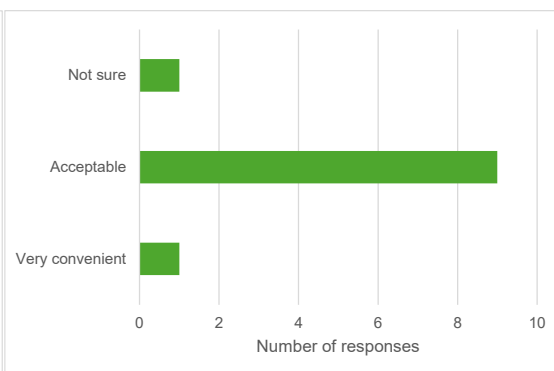


**Figure 4-11.** Flight schedule suitability.

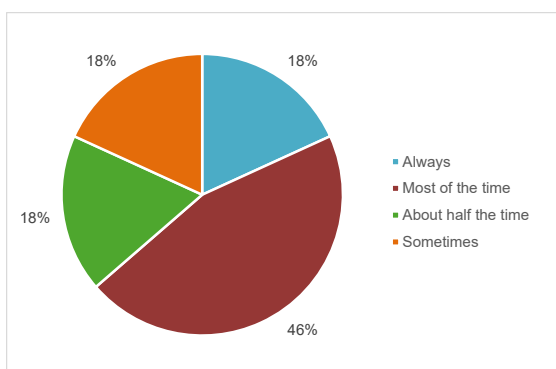


**Figure 4-12.** Reliability of the service.

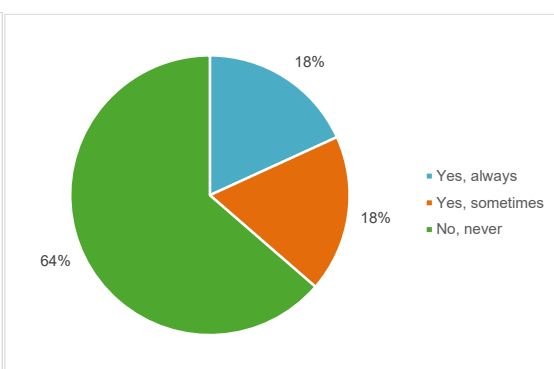


**Figure 4-13.** Same-day return.

For the **Medellín – Mompox** route, only two responses were received, which limits the depth of analysis. However, one participant viewed the flight frequency as adequate and the schedule as acceptable, while the other selected “not sure” for both questions. Both respondents had a positive view of the service’s reliability, with one indicating that flights are always on time and the other stating most of the time. Regarding airfare, one person found it very affordable and the other somewhat affordable. Neither respondent regularly travels and returns on the same day, although one mentioned doing so occasionally.

The **Cali – Timbiquí** route received just one response, which is not sufficient to reflect broader user opinions. While the single participant did provide answers to the questionnaire, the data from one individual is not enough to draw meaningful conclusions about service quality on this route.

Lastly, no responses were collected for the **Leticia – Tarapacá** route. This could be attributed to the route's extreme remoteness in the Amazon region, where internet access is limited, and digital participation is generally lower (Comini & Pérez, 2023). Furthermore, the primary method used to distribute the questionnaire, LinkedIn, may not have reached the communities or travellers most familiar with this route, potentially excluding key voices from the analysis.

#### 4.4.1.4 Accessibility

This block of the questionnaire explores how SATENA passengers access airports, the availability of alternative transport options, and their flexibility regarding flight itineraries. Most respondents (91%) reported reaching the airport at their destination by road, either with private or public transport (Figure 4-14). Only 9% mentioned walking or boat, indicating specific local contexts.

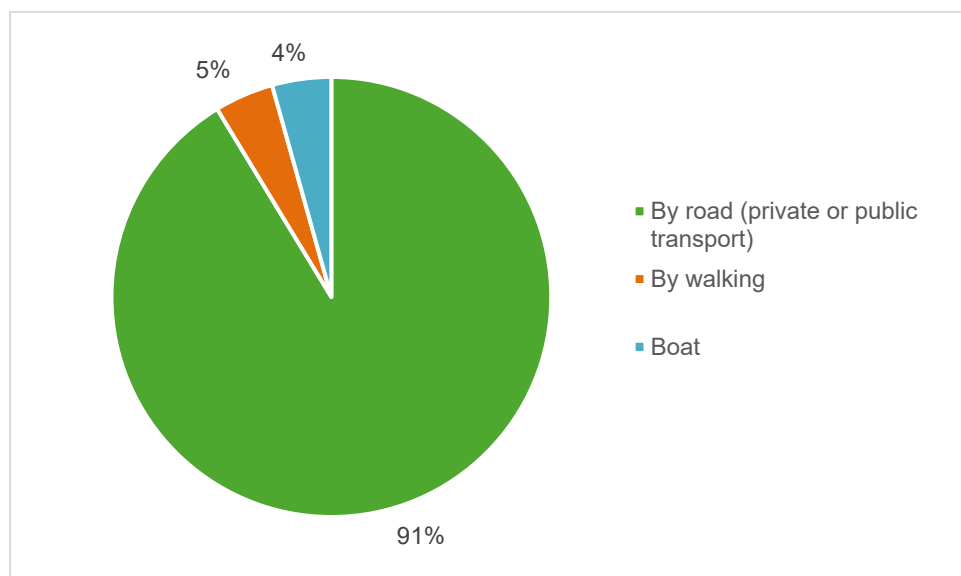


**Figure 4-14.** Mode of transport to/from the airport.

As seen in Figure 4-15, travel times from home to the airport were generally short: 10 respondents said less than 30 minutes, 9 said 30 minutes to 1 hour, and 4 indicated 1 to 2 hours.

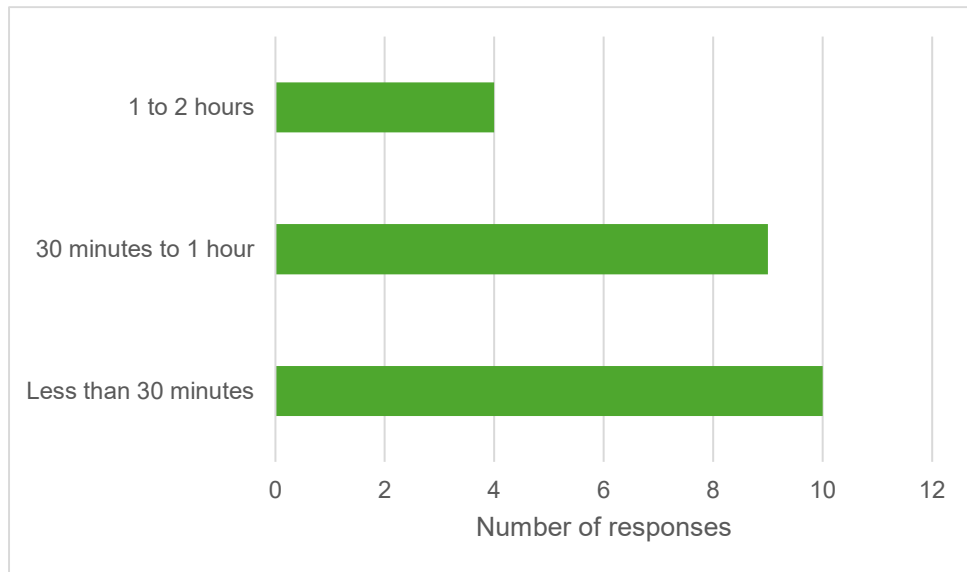


**Figure 4-15.** Travel time to airport from home.

When asked about alternatives if air transport were unavailable (Figure 4-16), the majority (57%) would use bus or road transport. Notably, 30% said they would not travel, underlining the importance of air services in maintaining regional connectivity. Only 13% (3 respondents) cited boat as a feasible alternative.

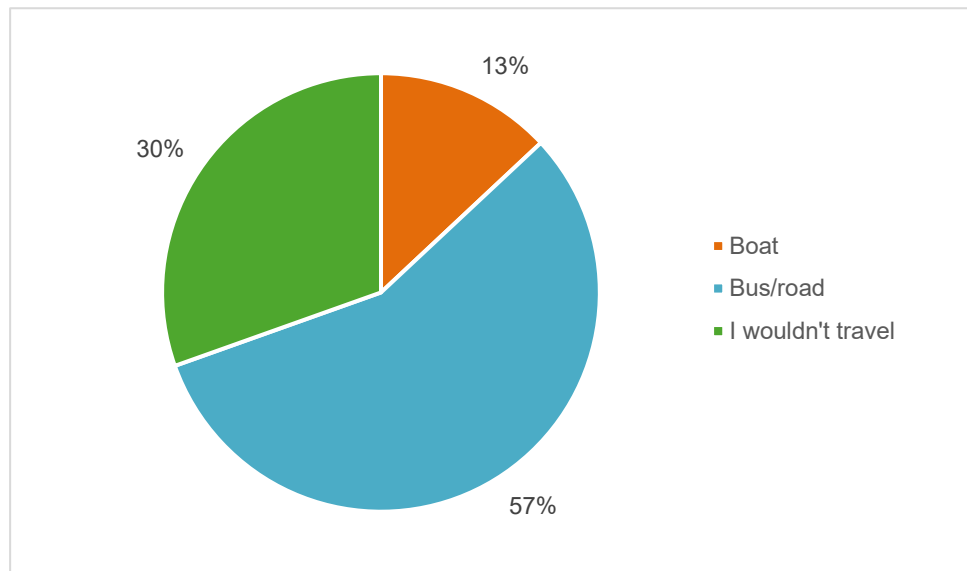


**Figure 4-16.** Alternative to air travel if unavailable.

Regarding preferences for stopovers, opinions were mixed (see Figure 4-17). While 31% said they wouldn't mind and 17% were fine with a short stop, 30% preferred a non-stop flight and 22% would avoid flights with stops. These results

suggest that while some flexibility exists, a significant portion of travellers still value direct connectivity.

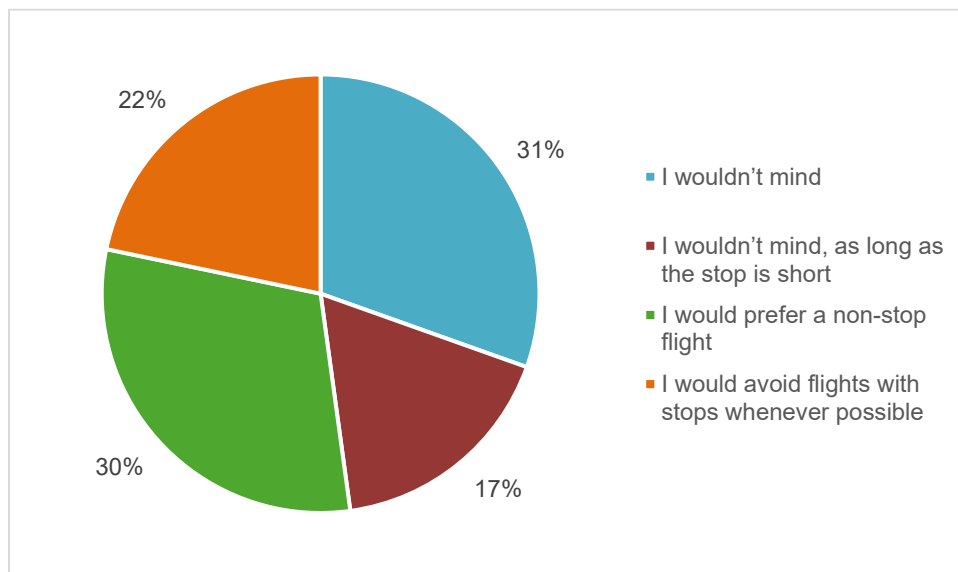


**Figure 4-17.** Acceptability of flights with a stopover.

At the end of the survey, participants were given an optional space to share additional comments about their experience with SATENA's services. The most common concerns raised included the limited frequency of flights, high airfares, and a lack of route diversity. Some respondents also mentioned aged aircraft, operational inefficiencies, and the absence of competition, which they believe contributes to elevated prices. Suggestions focused on expanding route coverage and improving flight schedules.

#### **4.4.2 Industry stakeholders questionnaire**

This questionnaire was also open for 20 days, from the 1<sup>st</sup> to the 21<sup>st</sup> of July 2025, and received a total of 40 responses. As with the SATENA users questionnaire, not all participants completed every question. However, all responses provided are considered valuable and have been included in the analysis where relevant.

##### **4.4.2.1 Respondent profile**

To better understand the background and expertise of the respondents, two initial questions were asked. When asked about the organisation they represented, the majority of respondents (17) indicated Aerocivil, followed by UPIT (5), SATENA

(4), and academia (2). Additionally, six participants selected “Other”, mostly referring to consultancy or infrastructure-related roles. These affiliations are illustrated in Figure 4-18.

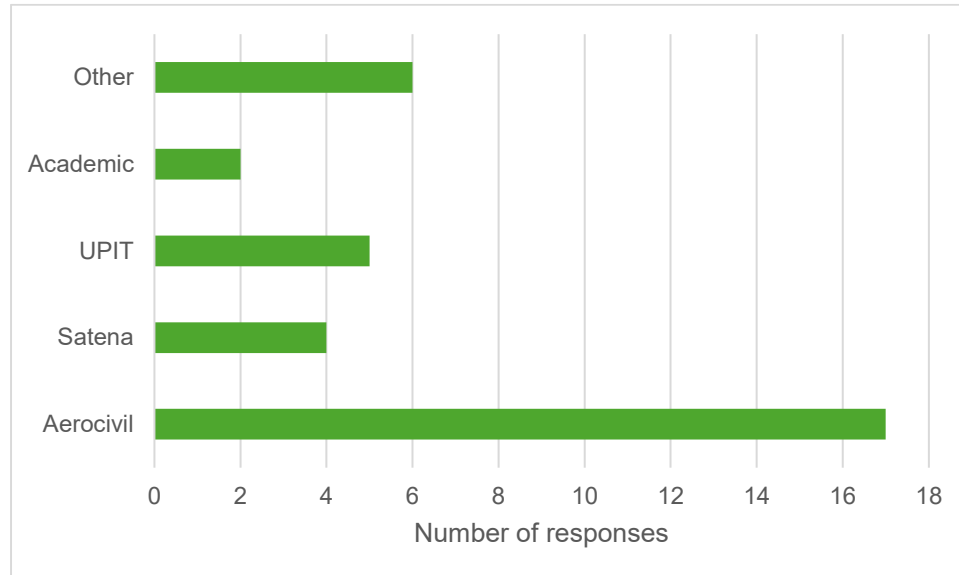


**Figure 4-18.** Respondents by organisation type.

In terms of their involvement with subsidised air transport, a diverse set of roles was represented (Figure 4-19). Multiple selections were allowed for this question, which is why the number of responses (59) exceeds the total number of participants. Policy and regulation, strategic planning, and data analysis or reporting were the most common areas, each selected by 9 respondents. Others reported working in route planning (6), service performance monitoring (6), and assessment of local transport needs (7). Two participants indicated roles in finance, and 11 respondents selected “Other”, including functions such as air traffic control, infrastructure projects, maintenance support, and aircraft registration.

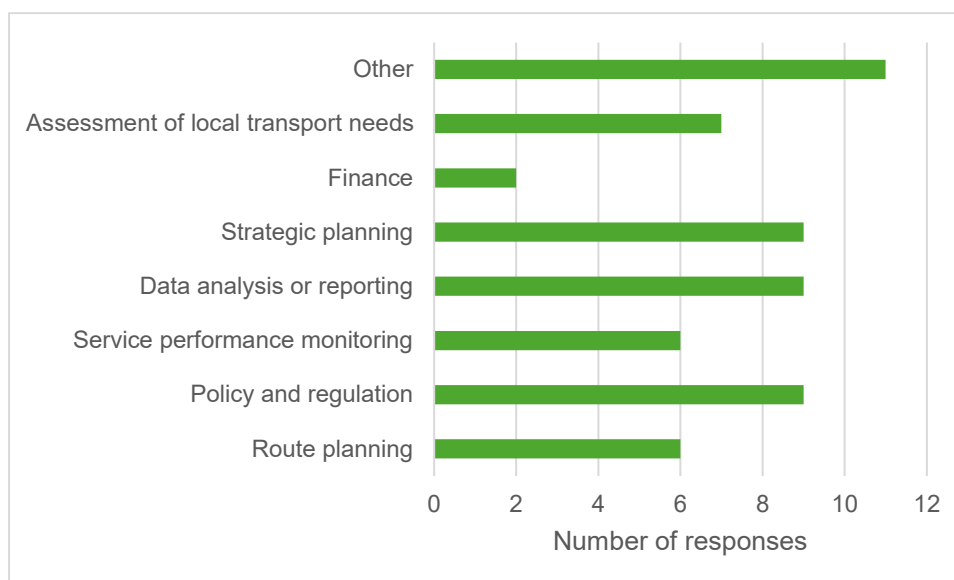


**Figure 4-19.** Roles related to subsidised air transport.

#### 4.4.2.2 Service variable evaluation

Before developing the classification framework, participants were asked to evaluate the importance of five key service variables. This initial assessment provided a useful understanding of industry priorities regarding air service quality in subsidised contexts. As shown in Table 4-11, stakeholders rated weekly frequency as the most important variable on average, followed by schedule, total flight time, aircraft type, and day-return possibility. While most variables received generally high scores, the standard deviation values suggest some variability in perceptions, particularly for total flight time and aircraft type.

**Table 4-11.** Stakeholder ratings of importance for service variables.

| Importance of variables (1-5)             | Average | Minimum | Maximum | Standard Deviation |
|-------------------------------------------|---------|---------|---------|--------------------|
| Frequency of flights (per week)           | 4.24    | 2       | 5       | 0.92               |
| Schedule (time of day)                    | 3.67    | 1       | 5       | 1.12               |
| Day-return possibility                    | 3.48    | 2       | 5       | 1.08               |
| Total flight time                         | 3.61    | 1       | 5       | 1.37               |
| Aircraft type (regional jet vs turboprop) | 3.52    | 1       | 5       | 1.16               |

These parameters were computed automatically by Qualtrics as part of the questionnaire results.

In addition, participants completed a series of pairwise comparisons to indicate which of two variables they considered more important. The results, summarised

in Figure 4-20, reinforce the prominence of weekly frequency, which was preferred over other variables in most comparisons. Preferences were more divided for pairs such as total flight time vs aircraft type and schedule vs day-return possibility, suggesting different perspectives depending on specific route or operational contexts.

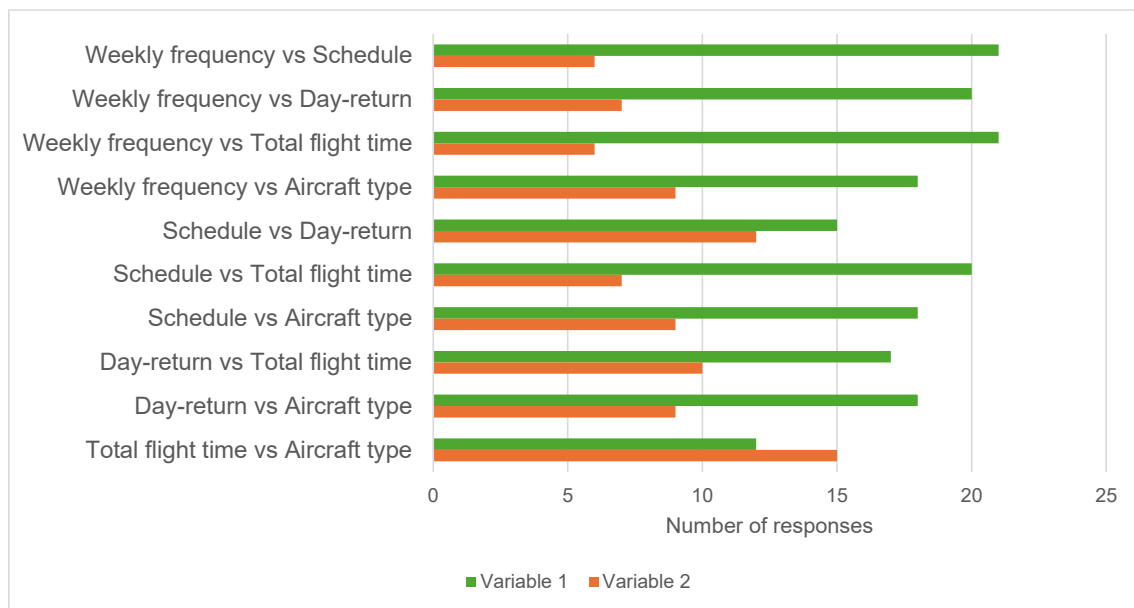


**Figure 4-20.** Preferred variable in pairwise comparisons.

These judgements form the basis for the upcoming multi-criteria evaluation methods presented in the next section.

#### 4.4.2.3 Route familiarity

As part of the questionnaire, participants were asked which of the five selected subsidised routes they were familiar with. As illustrated in Figure 4-21, the most recognised route was San Andrés – Providencia, with 13 respondents indicating familiarity, followed by Bogotá – Mitú (11 responses). Medellín – Mompox and Leticia – Tarapacá received six responses each, while Cali – Timbiquí was the least familiar, with five.

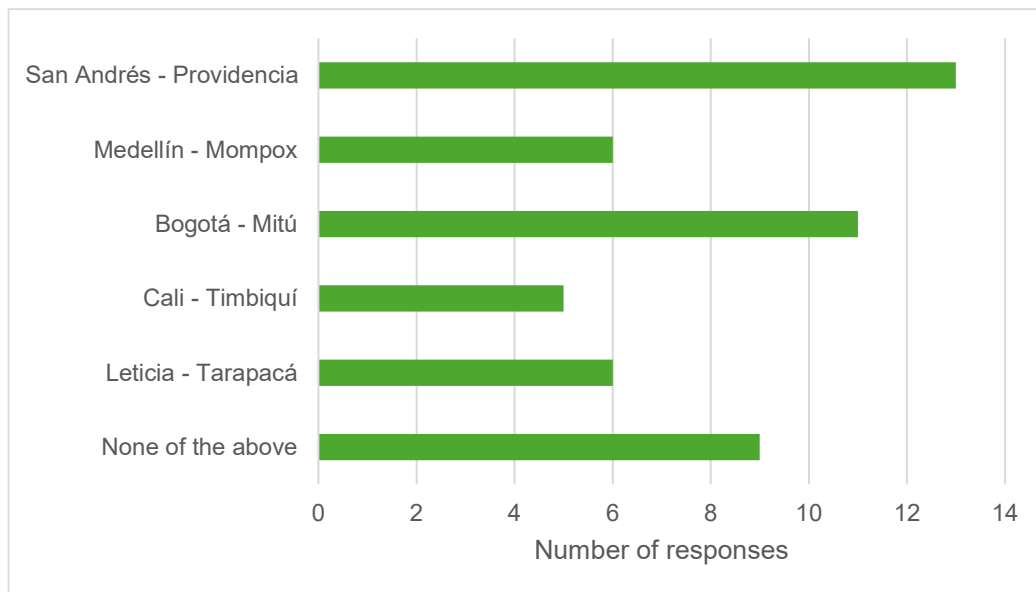


**Figure 4-21.** Stakeholder familiarity with case study routes.

Notably, nine respondents indicated that they were not familiar with any of the routes listed. These results highlight varying levels of stakeholder exposure to individual routes, which may influence their input in subsequent evaluations.

#### **4.4.2.4 Minimum acceptable service levels**

Next, industry stakeholders' views on minimum service levels for each of the five routes will be analysed.

##### **Bogotá – Mitú**

As seen in Figure 4-22, the majority of respondents (7 out of 11) suggested that 2-3 flights per week would be a sufficient minimum frequency for this route. A smaller number indicated a preference for 4-6 flights per week (2 responses), while another 2 participants recommended daily flights.

Regarding flight scheduling, early morning departures were the most selected option (9 responses). Mid-morning and midday to early afternoon received less support, with 4 and 2 responses respectively. When asked about the possibility of completing a round trip on the same day, most stakeholders (64%) believed it should be feasible a few days per week. Only 2 respondents supported having daily same-day return availability, while the remaining indicated it should be available only occasionally or were not sure.

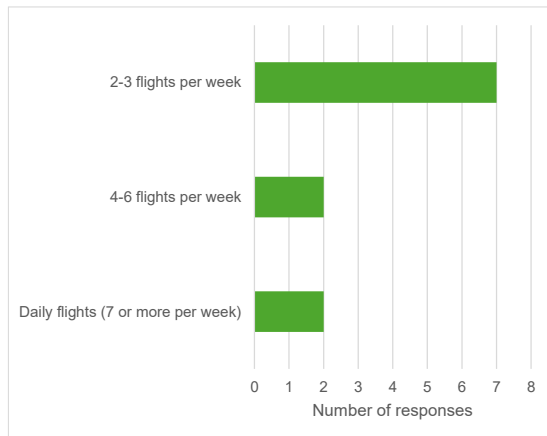


**Figure 4-22.** Minimum weekly frequency.

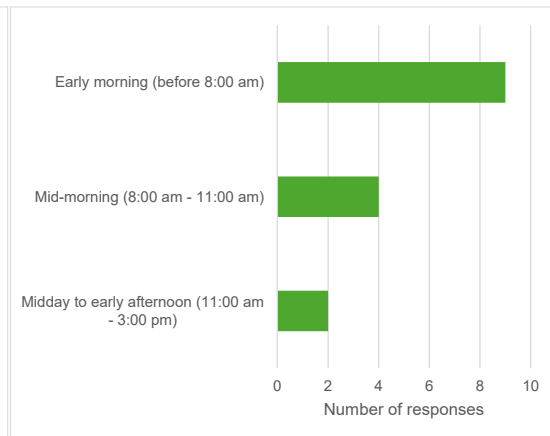


**Figure 4-23.** Preferred departure times.

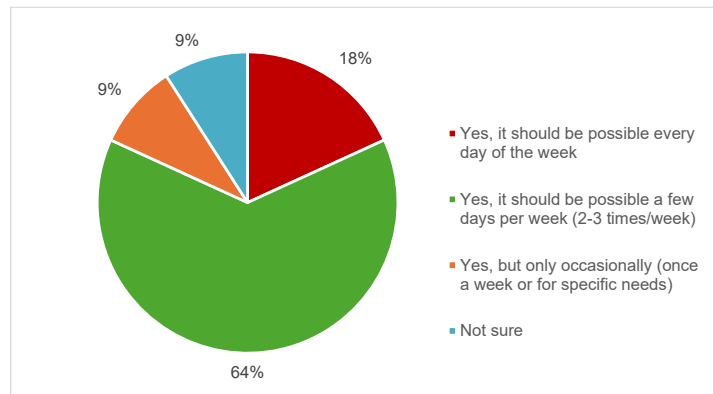


**Figure 4-24.** Same-day return possibility.

## San Andrés – Providencia

Stakeholders were divided on the minimum number of weekly flights needed for the San Andrés – Providencia route (Figure 4-25). While 6 respondents suggested 4-6 flights per week, 4 preferred 2-3 flights, and 3 indicated daily flights as the optimal minimum service level.

The majority of participants strongly favoured early morning departures, selected by 12 out of 13 respondents. This question allowed for multiple selections, so the total number of responses exceeds the number of respondents (13). Other options received less support, with midday to early afternoon chosen 5 times, late afternoon or evening twice, and mid-morning just once. Regarding same-day round trips, opinions were evenly split: 46% supported daily availability, another

46% preferred 2-3 times per week, and 8% stated that same-day returns are not necessary for this route.

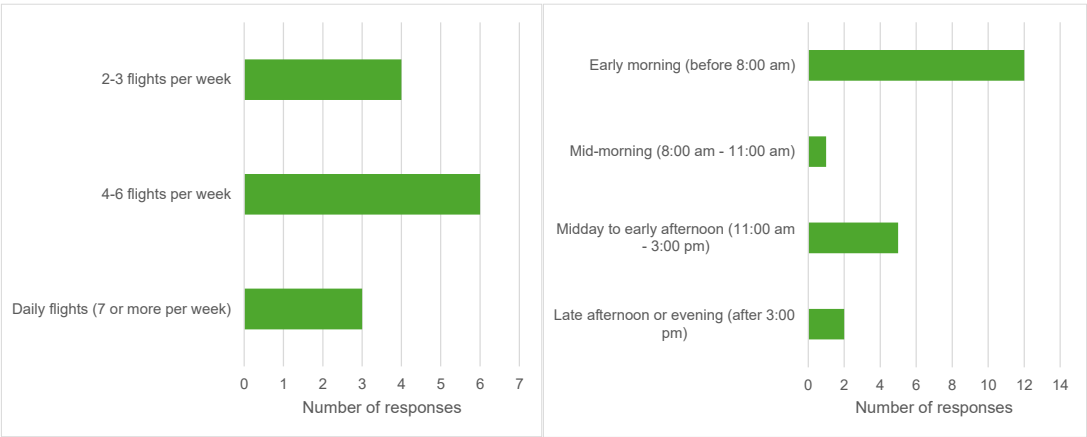


**Figure 4-25.** Minimum weekly frequency. **Figure 4-26.** Preferred departure times.

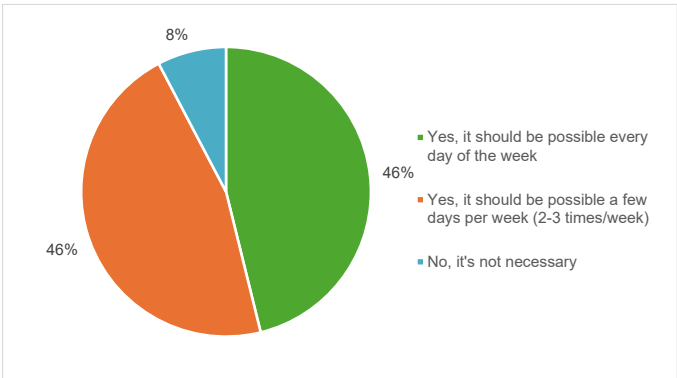


**Figure 4-27.** Same-day return possibility.

### Medellín – Mompox

For this route, the six stakeholders generally recommended a low to moderate minimum frequency (Figure 4-28). Three participants suggested offering 2-3 flights per week, two recommended 4-6 flights, and one indicated that a single weekly flight would be sufficient.

In terms of departure times, early morning was the most preferred option, selected by all the participants (see Figure 4-29). Additionally, three chose late afternoon or evening, and one selected midday to early afternoon. When asked about the need for same-day round trips, 50% supported this on a few days per

week. Two indicated it should be possible every day (33%), while one respondent felt it was not necessary for this route.

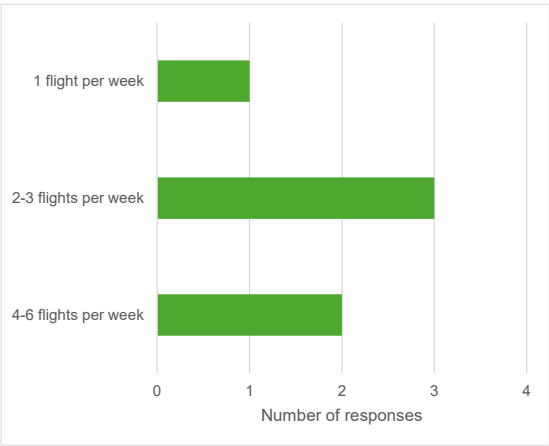


**Figure 4-28.** Minimum weekly frequency.

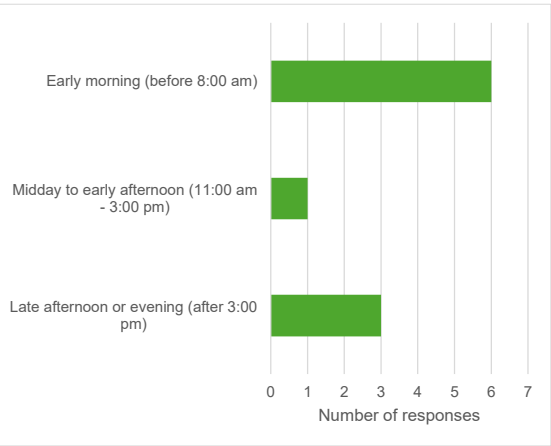


**Figure 4-29.** Preferred departure times.

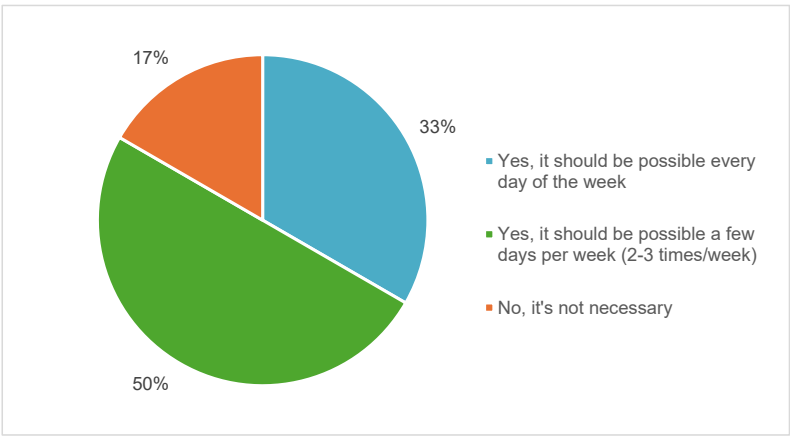


**Figure 4-30.** Same-day return possibility.

**Cali – Timbiquí**

This was the route with the lowest level of familiarity among respondents, with only five participants indicating they had knowledge of its operations, community needs, or performance. Despite the limited number of responses, their input provides useful insights.

All five respondents agreed that 2-3 flights per week would be an appropriate minimum service for this route (Figure 4-31). Regarding preferred departure times, four respondents selected early morning, while one respondent each also selected mid-morning, midday to early afternoon, and late afternoon or evening,

showing some diversity in scheduling preferences. As for day-return travel, three respondents (60%) believed this should be possible a few days per week, while one respondent supported daily return availability. Another indicated it should be possible only occasionally, suggesting a mix of views depending on operational feasibility or passenger needs.

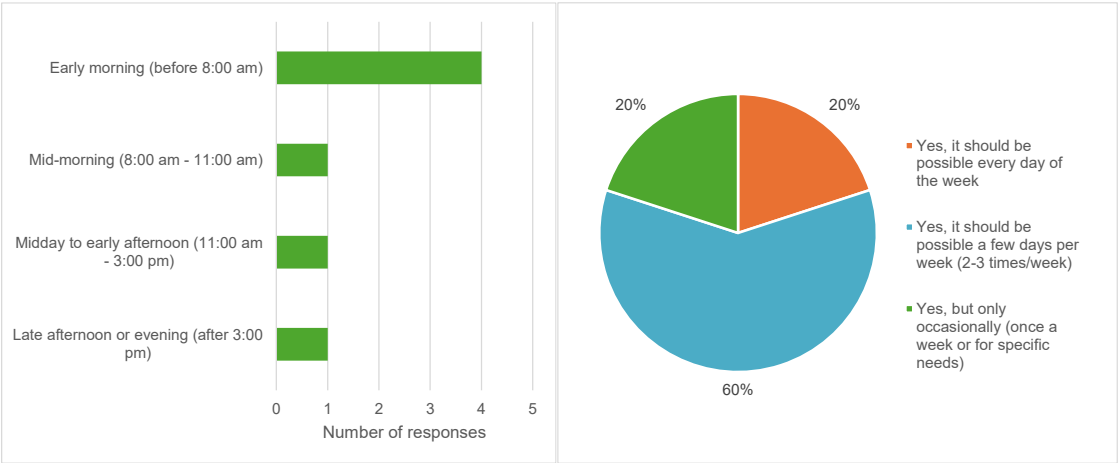


**Figure 4-31.** Preferred departure times.      **Figure 4-32.** Same-day return possibility.

### Leticia – Tarapacá

Stakeholder responses for this route suggest relatively modest expectations for minimum service levels, reflecting its lower traffic demand or specific regional context (Figure 4-33). When asked about the minimum number of weekly flights, four respondents indicated that one flight per week would be sufficient, while two recommended 2-3 weekly flights.

Regarding the preferred time of day for departures, early morning was clearly favoured, selected by four out of six respondents. Other time slots received minimal support from participants. As for same-day round trips, the majority did not see it as essential on this route. Two respondents (33%) suggested it should be possible a few days per week, another two felt it should be available only occasionally, and just one respondent supported offering the option every day of the week. One person was not sure, reinforcing the idea that travel demand on this route may be highly specific or limited.

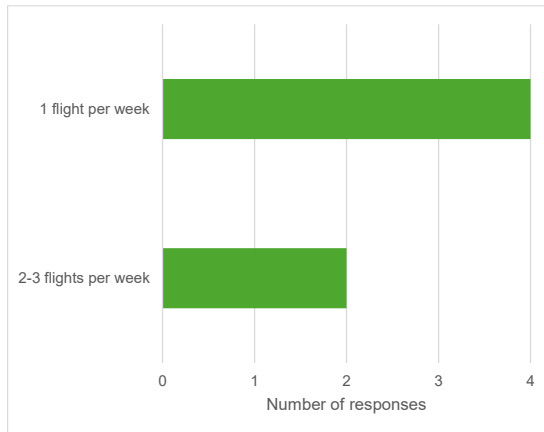


**Figure 4-33.** Minimum weekly frequency.

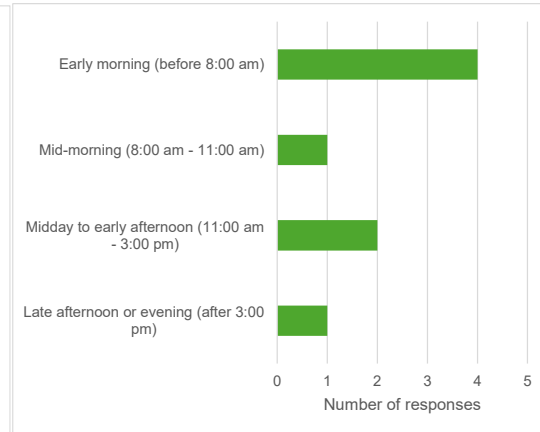


**Figure 4-34.** Preferred departure times.

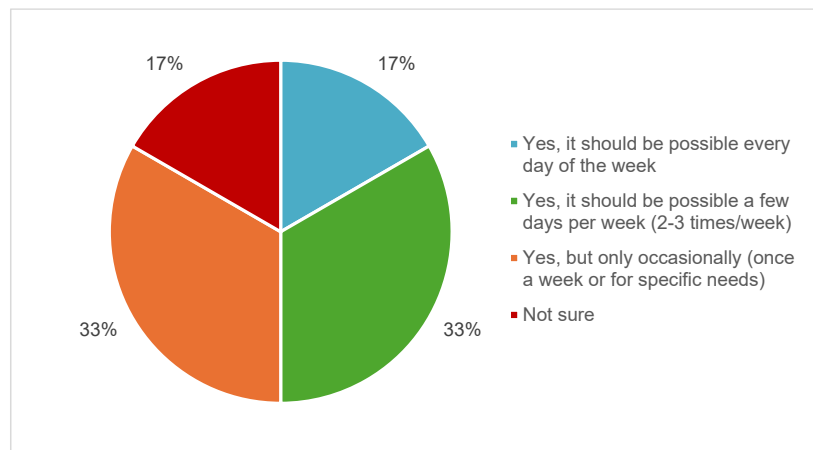


**Figure 4-35.** Same-day return possibility.

At the end of the survey, participants were invited to share additional comments. Several highlighted the importance of socio-economic factors when determining eligibility of subsidised routes, suggesting that subsidies should target users with demonstrated needs. Others emphasised that high ticket prices, limited flight frequencies, and inconsistent service reliability are key barriers that diminish the effectiveness of current subsidised air services. Concerns were also raised about SATENA's operational issues, such as flight cancellations and high operating costs in remote areas due to fuel and maintenance expenses.

Some respondents suggested ensuring the framework is applicable to all operators, including air taxis. There were also calls to consider infrastructure quality, technological adaptation, and the long-term viability of routes. These

insights provide valuable context for the development of the classification framework presented in the following section.

## 4.5 Development of service classification framework

This section presents the development of a classification framework designed to evaluate subsidised air services, including the weighting of key service attributes based on stakeholder input and the structure and logic of the scoring system.

### 4.5.1 Weighting of service attributes

The methodology and results used to quantify the relative importance of five key attributes of subsidised air services will be presented:

- Frequency of flights (per week)
- Schedule (time of day)
- Day-return possibility
- Total flight time
- Aircraft type (regional jet vs turboprop)

Two complimentary multi-criteria techniques were used: Weighted Sum Model (WSM) and the Analytic Hierarchy Process (AHP). The final weighting is based on a combination of both approaches.

#### 4.5.1.1 Weighted Sum Model (WSM)

To apply the WSM, stakeholders were asked to rate the importance of each attribute on a scale from 1 (Not important) to 5 (Very important). This method treats the variables independently and aggregates preferences by computing normalised average scores (Malefaki et al., 2025). Table 4-12 presents the average scores across all participants and the resulting WSM weights.

**Table 4-12.** WSM results and variable weights.

| Variables                       | Average score | WSM weight |
|---------------------------------|---------------|------------|
| Frequency of flights (per week) | 4.24          | 0.229      |
| Schedule (time of day)          | 3.67          | 0.198      |
| Day-return possibility          | 3.48          | 0.188      |
| Total flight time               | 3.61          | 0.195      |
| Aircraft type                   | 3.52          | 0.190      |

The most important service variable based on WSM was Frequency of flights, followed by Schedule and Total flight time. The differences between the lower-ranked attributes were relatively small.

#### 4.5.1.2 Analytic Hierarchy Process (AHP)

In parallel, the AHP method was applied. Participants were asked to make pairwise comparisons between all possible combinations of the five variables using the Saaty scale (1-9), where:

**Table 4-13.** Saaty scale (Saaty, 1987).

| Intensity | Definition                     |
|-----------|--------------------------------|
| 1         | Equal importance               |
| 3         | Moderate importance            |
| 5         | Essential or strong importance |
| 7         | Very strong importance         |
| 9         | Extreme importance             |
| 2,4,6,8,  | Intermediate values            |

Each comparison required choosing which of the two variables was more important, and by how much. The steps followed to compute the AHP weights are described below:

- 1. Data collection:** 27 participants completed all 10 pairwise comparisons (for 5 variables).
- 2. Adjustments of direction:** Saaty scores were converted based on the preferred variable. For example, if a participant preferred Schedule over Frequency and gave a score of 5, the adjusted value for Frequency vs Schedule was 1/5 (Adams, 2017; Saaty, 1987).
- 3. Aggregation of responses:** The adjusted scores for each pair were aggregated using the geometric mean ((4-1), following AHP best practices for group decision-making (Krejčí & Stoklasa, 2018; Whitaker, 2007).

$$\text{Geometric Mean} = \left( \prod_{i=1}^n x_i \right)^{\frac{1}{n}} \quad (4-1)$$

Where:

- $x_i$  is the value given by participant  $i$  for a specific pairwise comparison
- $n$  is the total number of participants

This formula was applied to each pairwise comparison, allowing the aggregation of individual judgments into a single representative score.

**4. Construction of pairwise comparison matrix:** A 5 x 5 reciprocal matrix was created using the aggregated geometric mean, as illustrated in Table 4-14:

**Table 4-14.** Pairwise comparison matrix.

|                   | Frequency | Schedule | Day-return | Total flight time | Aircraft type |
|-------------------|-----------|----------|------------|-------------------|---------------|
| Frequency         | 1         | 2.940    | 2.354      | 2.635             | 1.790         |
| Schedule          | 0.340     | 1        | 1.139      | 2.277             | 1.632         |
| Day-return        | 0.425     | 0.878    | 1          | 1.477             | 1.814         |
| Total flight time | 0.379     | 0.439    | 0.677      | 1                 | 0.797         |
| Aircraft type     | 0.559     | 0.613    | 0.551      | 1.254             | 1             |
| Sum of the column | 2.703     | 5.87     | 5.721      | 8.643             | 7.033         |

**5. Calculation of weights:** The priority vector (AHP weights) was obtained using the column normalisation method, a common approximation technique in AHP (Lipovetsky, 2020). This involves dividing each value in the pairwise comparison matrix (Table 4-14) by the sum of each column, summing the resulting values across each row, and finally normalising these row sums so that the total adds to 1. This provides an estimate of the relative importance of each variable, and the results are shown in Table 4-15.

**Table 4-15.** Normalised matrix and AHP weights.

| Normalised matrix | Frequency | Schedule | Day-return | Total flight time | Aircraft type | Sum of the row | AHP weight |
|-------------------|-----------|----------|------------|-------------------|---------------|----------------|------------|
| Frequency         | 0.370     | 0.501    | 0.411      | 0.305             | 0.255         | 1.842          | 0.368      |
| Schedule          | 0.126     | 0.170    | 0.199      | 0.263             | 0.232         | 0.991          | 0.198      |
| Day-return        | 0.157     | 0.150    | 0.175      | 0.171             | 0.258         | 0.910          | 0.182      |
| Total flight time | 0.140     | 0.075    | 0.118      | 0.116             | 0.113         | 0.562          | 0.112      |
| Aircraft type     | 0.207     | 0.104    | 0.096      | 0.145             | 0.142         | 0.695          | 0.139      |

The AHP weights reaffirm the importance of Frequency, followed by Schedule and Day-return possibility.

#### 4.5.1.3 Combined weights (WSM + AHP)

To balance subjective direct ratings and comparative judgement, the WSM and AHP weights were averaged for each attribute, obtaining the final weights in Table 4-16.

**Table 4-16.** Final variable weights.

| Variable          | AHP   | WSM   | Final Weight |
|-------------------|-------|-------|--------------|
| Frequency         | 0.368 | 0.229 | 0.299        |
| Schedule          | 0.198 | 0.198 | 0.198        |
| Day-return        | 0.182 | 0.188 | 0.185        |
| Total flight time | 0.112 | 0.195 | 0.154        |
| Aircraft type     | 0.139 | 0.190 | 0.165        |

The final weights offer a balanced view of stakeholder priorities by combining both methods. Frequency of flights stands out as the most important attribute overall, with a final weight of 0.299, reflecting its consistent high ranking in both methods. Schedule and Day-return possibility are valued similarly, suggesting that operational flexibility and convenience are key considerations. Aircraft type and Total flight time, though rated lower in AHP, received higher importance in the WSM responses, resulting in moderate final weights. This indicates that while technical or performance aspects are not top priorities in pairwise comparisons, they still carry meaningful influence when evaluated independently.

#### 4.5.2 Framework structure and logic

This section outlines the structure and functioning of the service classification framework develop the assess the adequacy of subsidised air transport routes.

The framework uses a quantitative approach to score each route across the five service variables, weights them according to stakeholder and user priorities, and aggregates the results into a total service score. Based on this score, the service level is classified into three categories: Basic, Adequate, or Optimal.

#### **4.5.2.1 Scoring method**

Each route is evaluated on the five key service variables:

- Weekly flight frequency
- Schedule (time of day)
- Day-return possibility
- Total flight time
- Aircraft type

Each variable is scored from 1 to 5 for each individual route, based on performance thresholds that are informed by the insights gathered from both SATENA users and industry stakeholders through the questionnaires. Rather than applying fixed thresholds across all routes, the scoring takes into account what respondents identified as appropriate or necessary for each specific context. For instance, while daily flights might score a 5 on some routes, on others, especially those with lower demand or more limited infrastructure, 2-3 weekly flights could be considered optimal and also receive a score of 5. This allows the framework to remain responsive to regional differences while maintaining a consistent scoring logic.

#### **4.5.2.2 Aggregation method**

To obtain a final service score for each route, the framework applies a weighted sum approach using the final variable weights presented in Table 4-16. For each route, the score assigned to each variable (based on its current performance) is multiplied by its corresponding weight. The total service score for each route is calculated as follows (Equation (4-2):

$$Total\ service\ score = \sum_{i=1}^n (S_i \times W_i) \quad (4-2)$$

Where:

- $S_i$  = Score of variable  $i$
- $W_i$  = Weight of variable  $i$  (from Table 4-16)
- $n$  = Total number of service variables (in this case, 5)

This total score provides a quantitative measure of overall service adequacy and is used to classify the route into one of three service categories.

#### **4.5.2.3 Classification thresholds**

The resulting total scores are then used to classify the route's service level into one of three categories:

##### **Basic service**

Score range: 0.0-2.4

These services fall short of stakeholder expectations and may require urgent improvements. Typically characterised by very low frequencies, limited timing options, or operational issues like poor regularity.

##### **Adequate service**

Score range: 2.5-3.9

Services that meet minimum standards in most areas but have room for improvement. They may meet user needs but fall short in some critical aspects (e.g. inconvenient scheduling or limited days of operation).

##### **Optimal service**

Score range: 4.0-5.0

High-quality services that align well with stakeholder and community expectations. These routes show strong performance across all variables and represent models of effective subsidised air transport.

Figure 4-36 shows the overall structure and logic of the service classification framework. It illustrates the step-by-step process through which input data on current route characteristics are translated into service scores and assigned to one of the three service categories. This framework provides a structured and replicable method for evaluating subsidised air services. The following section applies it to the five case study routes to assess their current service levels and identify areas for improvement.

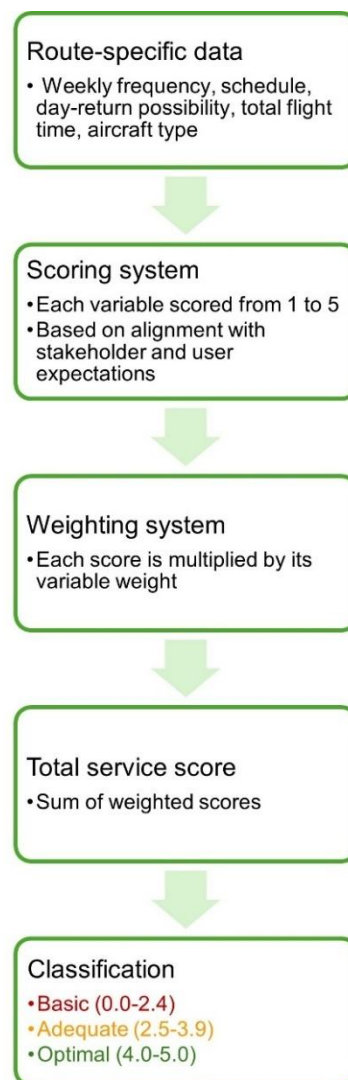


**Figure 4-36.** Service level classification framework.

## 4.6 Application of the framework to case study routes

The classification framework is now applied to the five case study routes to evaluate current service provision. Each route is assessed across the five defined variables, with scores assigned based on the alignment between existing services and stakeholder expectations. The results offer a structured and comparative perspective on how well each route is currently meeting user needs.

### 4.6.1 Route-level analysis

This analysis examines each case study individually, highlighting strengths and weaknesses in service provision by comparing current operations against questionnaires' outputs.

#### 4.6.1.1 Bogotá – Mitú

Frequency received a top score of 5, as the existing six flights per week exceed the majority's preference for 2-3 weekly flights, comfortably meeting demand expectations. Departure time suitability was rated 4, reflecting that while flights depart mostly after 8:00, stakeholders and users strongly preferred early morning departures. Therefore, the current schedule aligns well but misses the most favoured time window.

The feasibility of same-day round trip scored 1, indicating a significant service gap since current timings do not allow for round trip within a single day. Flight duration earned a score of 4, as the 1 hour 25 minutes direct flight is reasonable for this remote route and aircraft type, aligning with the flight duration scoring table developed for this study (Table 4-17). This table rates flight times on a scale from 1 (very long flights over 150 minutes) to 5 (short flights under 60 minutes).

**Table 4-17.** Flight duration score.

| Score | Criteria                                                             |
|-------|----------------------------------------------------------------------|
| 5     | ≤ 60 min – Short and efficient flight, preferred by most users       |
| 4     | 61–90 min – Still reasonable, acceptable for regional travel         |
| 3     | 91–120 min – Moderate, may cause fatigue but manageable              |
| 2     | 121–150 min – Long for a domestic regional flight, less desirable    |
| 1     | > 150 min – Very long, likely to reduce attractiveness of air travel |

Lastly, aircraft type was rated 5 because the Embraer jet provides great comfort for passengers. With all these scores combined, the final service score was computed as shown in Table 4-18. It can be seen that the route's service level is classified as adequate, reflecting a generally satisfactory but improvable service offering.

**Table 4-18.** Final service score and classification for the Bogotá – Mitú route.

| Variable              | Final weight | Bogotá-Mitú     |
|-----------------------|--------------|-----------------|
| Frequency             | 0.299        | 5               |
| Schedule              | 0.198        | 4               |
| Day-return            | 0.185        | 1               |
| Total flight time     | 0.154        | 4               |
| Aircraft type         | 0.165        | 5               |
| <b>Total score</b>    |              | <b>3.9</b>      |
| <b>Classification</b> |              | <b>Adequate</b> |

#### 4.6.1.2 San Andrés – Providencia

The San Andrés – Providencia route was evaluated using the same five service variables. Frequency received a score of 5, as the route offers 24 weekly flights, significantly exceeding both user and stakeholder expectations. Departure time suitability was also rated 5. Stakeholders expressed a preference for early departures, and the current schedule includes one early flight each day, along with other 2 or 3 daily flights, offering excellent flexibility.

Same-day round trip feasibility was rated 5, as passengers can complete a return trip while spending up to nine hours on either island, making this route very convenient for day travellers. Flight duration scored 5 as well, with a total flight time of approximately 40 minutes. Finally, aircraft type was rated 3, as the route is operated with ATR 42 turboprop aircraft. While suitable for short-haul regional operations, these aircraft offer a more basic level of comfort compared to regional jets. The final service score was 4.7, as seen in Table 4-19. The route's service level is therefore classified as optimal, reflecting a strong overall alignment with both operational and stakeholder expectations.

**Table 4-19.** Final service score and classification for the San Andrés – Providencia route.

| Variable              | Final weight | San Andrés-Providencia |
|-----------------------|--------------|------------------------|
| Frequency             | 0.299        | 5                      |
| Schedule              | 0.198        | 5                      |
| Day-return            | 0.185        | 5                      |
| Total flight time     | 0.154        | 5                      |
| Aircraft type         | 0.165        | 3                      |
| <b>Total score</b>    |              | <b>4.7</b>             |
| <b>Classification</b> |              | <b>Optimal</b>         |

#### 4.6.1.3 Medellín – Mompox

Frequency was rated 4 in this route, as the current offering of three weekly flights aligns with the lower end of stakeholder expectations, with some indicating that 2-3 flights per week would be enough, while others preferred 4-6 weekly services. Schedule scored 3, as only two of three weekly flights depart in early morning (Monday and Friday), while the Wednesday service operates in the afternoon, reducing schedule consistency.

Same-day round trips received a score of 2, as return flights on the same day are not possible on any operating day, and stakeholders indicated a preference for this option to be available at least a few days per week. Flight duration was rated 4, aligning with the criteria in Table 4-17 and the 1 hour and 7 minutes flight. Aircraft type received a score of 2, as the route is operated with Beechcraft B-1900 turboprop aircraft, which is smaller and less comfortable than the ATR 42. Table 4-20 shows a final score of 3.1 for this route, with a service level classified as adequate, suggesting room for improvement in both schedule and equipment while still providing a valuable connection.

**Table 4-20.** Final service score and classification for the Medellín – Mompox route.

| Variable              | Final weight | Medellín-Mompox |
|-----------------------|--------------|-----------------|
| Frequency             | 0.299        | 4               |
| Schedule              | 0.198        | 3               |
| Day-return            | 0.185        | 2               |
| Total flight time     | 0.154        | 4               |
| Aircraft type         | 0.165        | 2               |
| <b>Total score</b>    |              | <b>3.1</b>      |
| <b>Classification</b> |              | <b>Adequate</b> |

#### 4.6.1.4 Cali – Timbiquí

Frequency was rated 5 for the Cali – Timbiquí route, as the current schedule of three weekly flights aligns perfectly with stakeholder preferences, all of which indicated that 2-3 weekly flights would be appropriate. Departure time suitability also scored 5 as all flights depart at 7:00, matching the strong preference for early morning departures.

As for day-trip possibility, the variable scored 3. While a return trip is possible on all three operating days, the time available at destination is limited (between four and six hours). Flight duration received a score of 5, as the direct flight takes approximately 50 minutes which falls into the most efficient category as seen in Table 4-17. Aircraft type was rated 2 since the service is operated using Beechcraft B-1900 aircraft. The route's service level is classified as optimal, with a final score of 4.1, reflecting strong alignment with frequency and scheduling needs (Table 4-21).

**Table 4-21.** Final service score and classification for the Cali – Timbiquí route.

| Variable              | Final weight | Cali-Timbiquí  |
|-----------------------|--------------|----------------|
| Frequency             | 0.299        | 5              |
| Schedule              | 0.198        | 5              |
| Day-return            | 0.185        | 3              |
| Total flight time     | 0.154        | 5              |
| Aircraft type         | 0.165        | 2              |
| <b>Total score</b>    |              | <b>4.1</b>     |
| <b>Classification</b> |              | <b>Optimal</b> |

#### 4.6.1.5 Leticia – Tarapacá

The Leticia – Tarapacá route currently operates two weekly flights, which earned a frequency score of 4. While the majority of stakeholders considered one flight per week sufficient, others suggested 2-3 would be ideal. Departure time suitability was rated 3. Flights depart at 9:00, which falls slightly outside the preferred early morning window identified by most stakeholders. The possibility of completing a same-day round trip is not available, leading to a score of 2 for this variable. Stakeholders did not expect daily round-trip options, but many expressed a preference for at least limited availability during the week.

The flight duration, at approximately 45 minutes, is short and efficient, earning the maximum score of 5. As with several other regional routes, the service is operated using Beechcraft B-1900 aircraft, resulting in a score of 2. It is important to note that for this particular route, no responses were collected from users, so the evaluation is based exclusively on stakeholder input. Bringing all scores together, the final service score was calculated and is presented in Table 4-22. The route is classified as adequate, providing essential connectivity while highlighting areas for potential improvement in scheduling and flexibility.

**Table 4-22.** Final service score and classification for the Leticia – Tarapacá route.

| Variable              | Final weight | Leticia-Tarapacá |
|-----------------------|--------------|------------------|
| Frequency             | 0.299        | 4                |
| Schedule              | 0.198        | 3                |
| Day-return            | 0.185        | 2                |
| Total flight time     | 0.154        | 5                |
| Aircraft type         | 0.165        | 2                |
| <b>Total score</b>    |              | <b>3.3</b>       |
| <b>Classification</b> |              | <b>Adequate</b>  |

#### 4.6.2 Comparative summary

The comparative analysis of the five routes reveals clear patterns linked to connectivity and service quality, as summarised in Table 4-23. San Andrés – Providencia and Cali – Timbiquí achieve the highest total scores, classified as optimal, due to their high frequency, appropriate scheduling, and efficient flight

times, reflecting their role as well connected and busy routes. Conversely, Bogotá – Mitú, Medellín – Mompox, and Leticia – Tarapacá scored lower overall, classified as adequate, with notable weaknesses in day-return feasibility and aircraft type.

**Table 4-23.** Comparison of route-level service scores and assigned categories.

| Variable              | Bogotá-Mitú     | San Andrés-Providencia | Medellín-Mompox | Cali-Timbiquí  | Leticia-Tarapacá |
|-----------------------|-----------------|------------------------|-----------------|----------------|------------------|
| Frequency             | 5               | 5                      | 4               | 5              | 4                |
| Schedule              | 4               | 5                      | 3               | 5              | 3                |
| Day-return            | 1               | 5                      | 2               | 3              | 2                |
| Total flight time     | 4               | 5                      | 4               | 5              | 5                |
| Aircraft type         | 5               | 3                      | 2               | 2              | 2                |
| <b>Total score</b>    | <b>3.9</b>      | <b>4.7</b>             | <b>3.1</b>      | <b>4.1</b>     | <b>3.3</b>       |
| <b>Classification</b> | <b>Adequate</b> | <b>Optimal</b>         | <b>Adequate</b> | <b>Optimal</b> | <b>Adequate</b>  |

Frequency scores were generally high across all routes, indicating service levels that meet or exceed stakeholder expectations. Scheduling scores varied, with Medellín – Mompox and Leticia – Tarapacá rated lower due to less convenient departure times. Day-return capability was a key differentiator: routes offering same-day return options scored highest, while more isolated routes showed significant gaps. Flight duration scores were consistently strong across all routes. Aircraft type posed a limitation on less connected routes, where smaller turboprops are used, affecting comfort and service perception. Overall, these results highlight how connectivity and scheduling drive service quality, while infrastructure and aircraft choice restrict performance on remote routes.

## 4.7 Discussion

The following discussion reflects on the outcomes of applying the classification framework, exploring key findings, policy implications, and the framework's overall value and adaptability.

### 4.7.1 Interpretation of findings

The final classifications provide a snapshot of how current air services align with stakeholder expectations across five diverse routes. Two routes, San Andrés – Providencia and Cali – Timbiquí, were classified as Optimal, reflecting strong performance in key service areas such as frequency, scheduling, and the

possibility of same-day return. In particular, San Andrés – Providencia achieved the highest total score (4.7), consistent with its reliable connections, efficient flight time, and convenient departure times. In contrast, Leticia – Tarapacá, with the second lowest total score (3.3), was classified as Adequate, rather than Basic, due to strong scores in flight time and moderate frequency, despite lower evaluations in day-return feasibility and aircraft type.

Bogotá – Mitú and Medellín – Mompox also fell under the Adequate category, although with very different profiles. Bogotá – Mitú benefited from strong performance in frequency and aircraft type but was constrained by poor day-return feasibility. Medellín – Mompox, with a score of 3.1, the lowest among the five, showed key challenges in aircraft type and scheduling but was still classified as adequate under the flexible classification criteria. These results validate the framework's ability to highlight distinct strengths and weaknesses of each route while offering a flexible classification.

#### **4.7.2 Policy implications**

The application of the framework demonstrates its potential to inform route-level decisions on public service obligations and subsidies. By quantifying service adequacy using criteria that reflect both stakeholder priorities and technical performance, the model offers a structured way to justify differentiated levels of support. For example, although Leticia – Tarapacá received a mid-range total score, the low evaluation in accessibility variables such as day-return may suggest a need for targeted service improvements.

This tool could support institutions like SATENA and Aerocivil in identifying which routes may benefit most from enhanced investment, improved scheduling, or fleet upgrades. The transparent structure also allows for repeated assessments over time, offering a baseline for monitoring service evolution or the impact of policy changes. In this way, the framework strengthens evidence-based policymaking for regional air transport.

### **4.7.3 Evaluation of the framework**

A key strength of the framework lies in its balanced combination of stakeholder input and objective scoring, resulting in a tool that is participatory and analytically robust. The transparent weighting of variables and structured classification logic make it replicable for other route assessments. Additionally, the inclusion of flexible thresholds allows the tool to accommodate diverse geographic and operational contexts without compromising comparability.

Nonetheless, the approach has some limitations. The translation of qualitative service perceptions into quantitative scores involves some degree of subjectivity, particularly in cases where available data do not align with stakeholder expectations. Moreover, while the five selected variables capture a wide range of service features, other aspects such as reliability or pricing could further enrich the evaluation. Still, the framework offers a realistic and adaptable starting point for classifying and improving subsidised air services.

### **4.7.4 Replicability**

While designed for the Colombian context, this framework can be adapted to other countries with similar regional connectivity challenges. For example, nations such as Peru, Brazil, or Indonesia, all of which operate subsidised air networks in geographically complex regions, could apply the model by recalibrating variable weights through local stakeholder engagement and adjusting thresholds to match regional conditions. The modular structure allows users to substitute or include variables as needed, enhancing its adaptability. Ultimately, the framework presents a replicable tool to guide the evaluation and planning of subsidised air routes across a variety of national contexts.

## **4.8 Summary**

This chapter presented a comprehensive analysis of subsidised air services in Colombia through a multi-step approach. It began with the selection of representative case study routes and an assessment of their current service levels and regional needs. Insights from both SATENA users and industry stakeholders were incorporated to better understand expectations and priorities

regarding minimum service standards. Building on this foundation, a classification framework was developed using weighted service variables and applied to the five routes. The results highlighted strong differences in service adequacy, and the subsequent discussion reflected on key findings, policy implications, and the strengths and adaptability of the framework.

## **5 Conclusion**

This research set out to develop a framework to classify service levels for subsidised air transport routes in remote regions of Colombia. The core aim was to improve the alignment of subsidised air services with actual community needs, promoting efficiency, equity, and territorial integration. Each of the five objectives defined in the introduction was addressed through a mixed-methods approach, integrating both quantitative data and stakeholder perceptions.

### **5.1 Summary of main findings**

The analysis of five SATENA routes revealed significant disparities in service adequacy and community accessibility. Objective 1 of the research focused on evaluating current service provision, and this revealed that while established routes like Bogotá – Mitú and San Andrés – Providencia showed relatively high levels of frequency and reliability, newer or more remote connections such as Leticia – Tarapacá and Cali – Timbiquí exhibited limited frequency despite serving highly vulnerable populations. This suggests a clear misalignment in some cases between service provision and the depth of community need.

Across the routes analysed, there was strong evidence that socioeconomic vulnerability correlates with reliance on air transport. Regions such as Tarapacá and Timbiquí, which had the highest Multidimensional Poverty Index (MPI) scores and minimal road infrastructure, demonstrated the most critical need for air connectivity. In these areas, even low-frequency routes represented essential lifelines for accessing healthcare, education, and economic opportunity. The findings underscore that in many remote Colombian regions, air transport is not simply a matter of convenience, it is a basic public service that directly supports social inclusion and mobility. This addresses Objective 2, which focused on assessing the connectivity needs of remote communities.

The development and application of a service classification framework proved effective in capturing these complexities. By combining quantitative data with stakeholder and user input, the framework allowed for a flexible assessment of service adequacy tailored to each route's specific context. Variables such as flight

frequency, schedule convenience, and feasibility of same-day return were found to play a critical role in determining whether a service could be considered basic, adequate, or optimal. This reflects the achievement of Objective 3, which sought to identify and prioritise service quality variables, and Objective 4, which aimed to develop a classification framework that defines service levels using weighted variables.

Applying this model to the five case studies revealed that while some services were appropriately designed relative to community needs, others fell short due to inconvenient timing or lack of day-return possibility. This practical implementation corresponds to Objective 5, which involved applying the framework to selected routes to evaluate how current services aligned with the defined service levels.

These findings demonstrate the complexity and the urgency of establishing a more structured approach to managing Colombia's subsidised air network. They also confirm the value of incorporating community and stakeholder perspectives into the planning process.

## **5.2 Implications for policy and practice**

The findings of this research have important implications for how subsidised air transport is planned, managed, and evaluated in Colombia. One of the most urgent needs is the establishment of clearly defined service standards for routes serving remote regions. Currently, there is no formal threshold that defines what constitutes a minimum or adequate level of service. The framework developed in this study provides a practical tool that policymakers can use to set benchmarks. By doing so, authorities can ensure that regions with the greatest needs receive the level of air service necessary to support inclusion, mobility, and access to essential services.

Additionally, the study highlights the importance of integrating community perspectives into transport planning. While technical indicators such as frequency and load factor are valuable, they do not fully capture user experience or satisfaction. The incorporation of user survey data into the framework ensures that issues like schedule convenience, affordability, and accessibility are also

considered. This approach encourages a shift towards user-centred planning, in which local priorities and lived realities are taken into account alongside operational efficiency.

Finally, the classification framework developed here can serve as an ongoing monitoring tool for both SATENA and Aerocivil. Rather than evaluating subsidised air routes only at the time of launch or during policy revisions, the framework can be applied regularly to assess whether services continue to meet expectations over time. As demographic conditions, infrastructure, and demand patterns evolve, this flexible monitoring will be essential to maintaining effective connectivity strategies. The framework supports not only short-term policy decisions but also long-term planning and performance evaluation.

### **5.3 Relation to the existing literature**

This study builds on international models such as the U.S. Essential Air Services (EAS) programme and the European Union's Public Service Obligation (PSO) framework. Like previous research by Wittman et al. (2016) and Bråthen and Eriksen (2018), this research confirms the importance of route-level analysis and the need for flexible service benchmarks. However, unlike many international models that rely heavily on connectivity to major hubs, the Colombian case shows the necessity of adapting frameworks to regions where they may be no viable alternatives.

The framework proposed addresses a notable gap in the Colombian academic and policy literature, which until now lacked a structured approach for evaluating the adequacy of subsidised air routes based on both operational metrics and community needs. It also contributes to a growing international conversation about how to design equitable, sustainable, and locally responsive air transport policies.

### **5.4 Limitations of the study**

While this study offers insightful contributions, certain limitations must be acknowledged. One of the most notable constraints was the limited response rate to the user and stakeholder surveys. In particular, responses from users of newer

or more remote routes, were modest. This may be due to barriers such as internet access, low digital literacy, and reduced online engagement with highly isolated regions like the Amazon, which constrained the representativeness of user perspectives.

Another limitation relates to the scope of the case studies. The analysis focused on five routes selected for their diversity in geography, service maturity, and community characteristics. While this provided a diversity of conditions, the limited number of routes means that findings cannot be fully generalised across the entire subsidised route.

An additional challenge was the incomplete availability of data for some routes, particularly on operational costs and financial performance. The absence of such information made it difficult to incorporate cost-efficiency metrics alongside the service adequacy assessment. This represents an important gap when considering policy recommendations related to public subsidy allocation. The temporal scope of the study also presents a limitation. The data and analysis reflect a snapshot of service conditions within a single year, during which recent routes had just been launched. As air routes evolve and government priorities shift, further monitoring will be required to track long-term trends.

Finally, the analysis focused exclusively on regular scheduled air services operated by SATENA. Other critical modes of transport, such as emergency flights, charter services, or even river transport were beyond the scope of this research. These services may play an important role in some communities and should be considered in future connectivity assessments.

Despite these limitations, the research provides a solid foundation for further work and practical applications in regional transport planning.

## **5.5 Recommendations for future research**

Building on the findings and limitations of this study, several directions for future research emerge. One clear opportunity lies in expanding the scope of the framework to include a larger number of routes across Colombia. Applying the classification model on a national scale would provide a more comprehensive

understanding of connectivity gaps and service disparities. A wider application could also help to refine the service level thresholds and improve their sensitivity to different regional contexts.

Future studies could also benefit from incorporating financial and operational cost data into the analysis. Integrating subsidy amounts, route profitability, and cost per passenger data would allow for a more balanced assessment of both social impact and economic feasibility.

Another valuable area for future work involves prioritising deeper community engagement, particularly in underrepresented or digitally excluded areas. While this study incorporated surveys from users and stakeholders, response rates were uneven across routes. Future projects could use focus groups, interviews, or community workshops to gather more qualitative insights into how residents perceive and experience air services. This would strengthen the demand side of service planning and help ensure that frameworks are shaped to local realities.

Lastly, expanding the analysis to consider multimodal connectivity would provide a more integrated view of regional accessibility. In many of Colombia's remote areas, air transport interacts with river and road transport systems. Future studies could examine how air services fit within these broader networks and whether hybrid models of mobility can offer more cost-effective solutions.

## **5.6 Final remarks**

In a country where entire communities rely on air travel for access to basic services, it is not enough to rely on historical precedents or political pressures to decide where and how to subsidise air routes. This thesis contributes a practical, adaptable, and evidence-based tool for doing better.

By focusing on service adequacy rather than simple coverage, and by accounting for local needs and stakeholder opinions, this research provides policymakers and planners with a framework to support more transparent, equitable, and effective use of public funds in Colombia's subsidised air transport system.

## References

- Adams, B. (2017, November 15). The AHP Pairwise Process. *DLProdTeam*.  
<https://medium.com/dlprodteam/the-ahp-pairwise-process-c639eadcbd0e>
- Adler, M., Behrens, C., & Kieffer, M. (2025). *Air access to remote Finnish and European regions*. <https://www.seo.nl/en/publications/air-access-to-remote-finnish-and-european-regions-the-economic-impact-of-air-accessibility-at-jyvaskyla-kemi-tornio-and-kokkola-pietarsaari-airport/>
- Aerocivil. (2023). *Resolución Número 01668*. Diario Oficial Colombia.  
<https://www.aerocivil.gov.co/loader.php?IServicio=Tools2&ITipo=descargas&IFuncion=visorpdf&file=https%3A%2F%2Fwww.aerocivil.gov.co%2Floader.php%3FIServicio%3DTools2%26ITipo%3Ddescargas%26IFuncion%3DexposeDocument%26idFile%3D24135%26tmp%3D7ff9c97643f8a4f05ba5e696254d25d3%26urlDeleteFunction%3Dhttps%253A%252F%252Fwww.aerocivil.gov.co%252Floader.php%253FIServicio%253DTools2%2526ITipo%253Ddescargas%2526IFuncion%253DdeleteTemporalFile%2526tmp%253D7ff9c97643f8a4f05ba5e696254d25d3&pdf=1&tmp=7ff9c97643f8a4f05ba5e696254d25d3&fileItem=24135>
- Aerocivil. (2025). *Estadísticas de oferta y demanda—Transporte de pasajeros*. Aerocivil. <https://www.aerocivil.gov.co/documentos/1242/ano-2025/>
- Alkhatib, S., & Migdadi, Y. (2018). Operational Determinants of Airline Service Quality: Worldwide Cross-Regional Analysis. *Quality Management Journal*, 25, 186–200. <https://doi.org/10.1080/10686967.2018.1515525>

ArcGIS. (2025). *GIS Mapping Software | Create Web Maps with ArcGIS Online*  
[Computer software]. <https://www.esri.com/en-us/arcgis/products/arcgis-online/overview>

Babakus, E., & Boller, G. W. (1992). An empirical assessment of the SERVQUAL scale. *Journal of Business Research*, 24(3), 253–268.  
[https://doi.org/10.1016/0148-2963\(92\)90022-4](https://doi.org/10.1016/0148-2963(92)90022-4)

Bilotkach, V., & Bush, H. (2020). Airport competition from airports' perspective: Evidence from a survey of European airports. *Competition and Regulation in Network Industries*, 21(3), 275–296.  
<https://doi.org/10.1177/1783591720937876>

Birolini, S., Avogadro, N., Malighetti, P., & Paleari, S. (2024). Con-Accessibility: Logit-based catchment area modeling for strategic airport system planning. *Transportation Research Part A: Policy and Practice*, 190, 104270. <https://doi.org/10.1016/j.tra.2024.104270>

Boston Brand Research & Media. (2025). *SATENA Honored as “Leader in Enhancing Accessibility in Colombian Air Travel – Colombia, 2024” by Global Brand Frontier Awards*.  
<https://www.bostonbrandmedia.com/news/satena-honored-as-leader-in-enhancing-accessibility-in-colombian-air-travel---colombia-2024-by-global-brand-frontier-awards>

Bråthen, S. (2011, April 30). *Air Transport Services in Remote Regions*.  
[https://www.oecd.org/en/publications/air-transport-services-in-remote-regions\\_5kg9mq3xcrrx-en.html](https://www.oecd.org/en/publications/air-transport-services-in-remote-regions_5kg9mq3xcrrx-en.html)

- Bråthen, S., & Eriksen, K. S. (2018). Regional aviation and the PSO system – Level of Service and social efficiency. *Journal of Air Transport Management*, 69, 248–256.  
<https://doi.org/10.1016/j.jairtraman.2016.10.002>
- Cámara de Comercio de Medellín. (2024). *Economía de Antioquia se estima un crecimiento en el 2024 impulsado por los empresarios*.  
<https://www.camaramedellin.com.co/noticias/economia-de-antioquia-se-estima-un-crecimiento-en-el-2024-impulsado-por-los-empresarios>
- Cattaneo, A., Adukia, A., Brown, D. L., Christiaensen, L., Evans, D. K., Haakenstad, A., McMenomy, T., Partridge, M., Vaz, S., & Weiss, D. J. (2022). Economic and social development along the urban–rural continuum: New opportunities to inform policy. *World Development*, 157, 105941. <https://doi.org/10.1016/j.worlddev.2022.105941>
- Chandra Mahapatra, S., & Bellamkonda, R. S. (2023). Higher expectations of passengers do really sense: Development and validation a multiple scale-FliQual for air transport service quality. *Journal of Retailing and Consumer Services*, 70, 103162.  
<https://doi.org/10.1016/j.jretconser.2022.103162>
- Chen, Y., Yang, H., Zheng, S., Wang, K., & Jiang, C. (2025). Fostering the connectivity on thin routes: Should regional airlines cooperate with network airlines or with local governments? *Transportation Research Part B: Methodological*, 195, 103191.  
<https://doi.org/10.1016/j.trb.2025.103191>

- Comini, N., & Pérez, A. R. (2023). How to improve internet access in the Amazonas department in Colombia? *World Bank Blogs*.  
<https://blogs.worldbank.org/en/latinamerica/improve-internet-access-amazonas-colombia>
- DANE. (2021). *DANE - Estadísticas experimentales: Proporción de la población rural que vive a menos de 2 km de una carretera transitable todo el año*.  
<https://www.dane.gov.co/index.php/estadisticas-por-tema/estadisticas-experimentales>
- DANE. (2025). *DANE - Pobreza y condiciones de vida*.  
<https://www.dane.gov.co/index.php/estadisticas-por-tema/pobreza-y-condiciones-de-vida>
- Das, A. K., Bardhan, A. K., & Fageda, X. (2020). New regional aviation policy in India: Early indicators and lessons learnt. *Journal of Air Transport Management*, 88, 101870.  
<https://doi.org/10.1016/j.jairtraman.2020.101870>
- Deboosere, R., & El-Geneidy, A. (2018). Evaluating equity and accessibility to jobs by public transport across Canada. *Journal of Transport Geography*, 73, 54–63. <https://doi.org/10.1016/j.jtrangeo.2018.10.006>
- Departamento Nacional de Planeación. (2023). *Plan Nacional de Desarrollo 2022-2026*.  
<https://colaboracion.dnp.gov.co/CDT/Prensa/Publicaciones/plan-nacional-de-desarrollo-2022-2026-colombia-potencia-mundial-de-la-vida.pdf>

- Díaz Olariaga, O. (2021). The Role of Regional Airports in Connectivity and Regional Development. *Periodica Polytechnica Transportation Engineering*, 49(4), 394–406. <https://doi.org/10.3311/PPtr.16557>
- Díaz Olariaga, O., & Alonso-Malaver, C. (2022). Impact of airport policies on regional development. Evidence from the Colombian case. *Regional Science Policy & Practice*, 14(6), 185–211. <https://doi.org/10.1111/rsp3.12483>
- Díaz Olariaga, O., Bolívar, N., Gutiérrez, R. M., & Galeana, O. R. (2018). Gravitational analysis of the air transport network. Application to the case of Colombia. *Transportation Research Procedia*, 33, 51–58. <https://doi.org/10.1016/j.trpro.2018.10.075>
- Díaz Olariaga, O., & Carvajal, A. F. (2016). *Efectos de la liberalización en la geografía del transporte aéreo en Colombia*. 55(2), 344–364.
- Dožić, S., & Kalić, M. (2014). An AHP Approach to Aircraft Selection Process. *Transportation Research Procedia*, 3, 165–174. <https://doi.org/10.1016/j.trpro.2014.10.102>
- Duque, J. C., García, G. A., Lozano-Gracia, N., Quiñones, M., & Montoya, K. Y. (2023). Inequality and space in a highly unequal country: What does the literature tell us in the context of Colombia? *Regional Science Policy & Practice*, 15(9), 2065–2087. <https://doi.org/10.1111/rsp3.12681>
- Eisenhut, D., Moebs, N., Windels, E., Bergmann, D., Geiß, I., Reis, R., & Strohmayer, A. (2021). Aircraft Requirements for Sustainable Regional

Aviation. *Aerospace*, 8(3), Article 3.

<https://doi.org/10.3390/aerospace8030061>

European Commission. (2024). *Public Service Obligations (PSOs)—European Commission*.

[https://transport.ec.europa.eu/document/download/9168af3e-67c7-430f-b46c-61b76236d8cb\\_en](https://transport.ec.europa.eu/document/download/9168af3e-67c7-430f-b46c-61b76236d8cb_en)

Fageda, X., Jiménez, J. L., & Valido, J. (2017). An empirical evaluation of the effects of European public policies on island airfares. *Transportation Research Part A: Policy and Practice*, 106, 288–299.

<https://doi.org/10.1016/j.tra.2017.09.018>

Fageda, X., Suárez-Alemán, A., Serebrisky, T., & Fioravanti, R. (2018). Air connectivity in remote regions: A comprehensive review of existing transport policies worldwide. *Journal of Air Transport Management*, 66, 65–75. <https://doi.org/10.1016/j.jairtraman.2017.10.008>

Fageda, X., Suárez-Alemán, A., Serebrisky, T., & Fioravanti, R. (2019). Air transport connectivity of remote regions: The impacts of public policies. *Regional Studies*, 53(8), 1161–1169.

<https://doi.org/10.1080/00343404.2018.1556391>

Hromádka, M. (2017). Definition of Public Service Obligation potential in the new EU member states. *Transport Problems*, 12(1), 5–13.

<https://doi.org/10.20858/tp.2017.12.1.1>

IATA. (2019). *The Value of Air Transport in Colombia*.

<https://www.iata.org/contentassets/bbff04f2b67140638dff0b5cc5fc8e1/the-value-of-air-transport-in-colombia.pdf>

IATA. (2022). *IATA Level of Service (LoS) Best Practice*.

<https://www.iata.org/contentassets/d1d4d535bf1c4ba695f43e9beff8294f/iata-level-of-service-paper-best-practice.pdf>

Ivarsson, E., Rubiano, L. C., & Maties, C. M. (2023). *When the nearest school or hospital is hours away... Making the case for better transport in rural Colombia*. World Bank Blogs.

<https://blogs.worldbank.org/en/transport/when-nearest-school-or-hospital-hours-away-making-case-better-transport-rural-colombia>

Jiménez, J. L., Valido, J., & Pellicer, A. A. (2023). Evaluating the effect of air transport resident subsidies on non-residents tourists' expenditure. *Journal of Air Transport Management*, 106, 102319.

<https://doi.org/10.1016/j.jairtraman.2022.102319>

Kölker, K., Bießlich, P., & Lütjens, K. (2016). From passenger growth to aircraft movements. *Journal of Air Transport Management*, 56, 99–106.

<https://doi.org/10.1016/j.jairtraman.2016.04.021>

Konidari, P., & Mavrakakis, D. (2007). A multi-criteria evaluation method for climate change mitigation policy instruments. *Energy Policy*, 35(12), 6235–6257. <https://doi.org/10.1016/j.enpol.2007.07.007>

Krejčí, J., & Stoklasa, J. (2018). Aggregation in the analytic hierarchy process:

Why weighted geometric mean should be used instead of weighted arithmetic mean. *Expert Systems with Applications*, 114, 97–106.

<https://doi.org/10.1016/j.eswa.2018.06.060>

Leandro, F., Andrade, A. R., & Kalakou, S. (2021). Designing aviation networks under Public Service Obligations (PSO): A case study in Greece. *Journal of Air Transport Management*, 93, 102042.

*Journal of Air Transport Management*, 93, 102042.

<https://doi.org/10.1016/j.jairtraman.2021.102042>

Leao, C., Andrade, M. D. O., Falcão, V., & Silva, C. F. A. D. (2022). Utility of Subsidized Airlines to Remote Locations as a Means of Classification as Lifelines. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4006886>

Leão e Silva, C. J., de Andrade, M. O., Falcão, V. A., & da Silva, C. F. A.

(2022). The geographical characteristics of subsidized air routes serving as lifelines. *Journal of Air Transport Management*, 104, 102280.

<https://doi.org/10.1016/j.jairtraman.2022.102280>

Lipovetsky, S. (2020). Priority vector estimation: Consistency, compatibility, precision. *International Journal of the Analytic Hierarchy Process*, 12.

<https://doi.org/10.13033/ijahp.v12i3.801>

Malefaki, S., Markatos, D., Filippatos, A., & Pantelakis, S. (2025). A

Comparative Analysis of Multi-Criteria Decision-Making Methods and Normalization Techniques in Holistic Sustainability Assessment for Engineering Applications. *Aerospace*, 12(2), Article 2.

<https://doi.org/10.3390/aerospace12020100>

- Matisziw, T. C., Lee, C.-L., & Grubescic, T. H. (2012). An analysis of essential air service structure and performance. *Journal of Air Transport Management*, 18(1), 5–11.  
<https://doi.org/10.1016/j.jairtraman.2011.05.002>
- Merkert, R., & O'Fee, B. (2013). Efficient procurement of public air services—Lessons learned from European transport authorities' perspectives. *Transport Policy*, 29, 118–125.  
<https://doi.org/10.1016/j.tranpol.2013.04.008>
- Merkert, R., & O'Fee, B. (2016). Managerial perceptions of incentives for and barriers to competing for regional PSO air service contracts. *Transport Policy*, 47, 22–33. <https://doi.org/10.1016/j.tranpol.2015.12.002>
- Ministry of Transport Malaysia. (2025). *Rural Air Services (RAS)*.  
<https://www.mot.gov.my/en/aviation/operators/RAS>
- Mueller, F. (2021). Accessibility for money? An evaluation of subsidized air transport services in Europe and the United States. *Transport Policy*, 106, 153–164. <https://doi.org/10.1016/j.tranpol.2021.03.023>
- OAG. (2025a). *OAG Mapper*. <https://analytics.oag.com/analyser-client/mapper/mapper-report>
- OAG. (2025b). *OAG Power Table Report*. <https://analytics.oag.com/analyser-client/schedules-analyser/powertables-report>
- OECD. (2022). *Building and financing the transport infrastructure of tomorrow: The case of Colombia* (OECD Development Policy Papers). Organisation

for Economic Co-Operation and Development (OECD).

<https://doi.org/10.1787/3292ad01-en>

Özcan, İ. Ç. (2014a). A community evaluation of Essential Air Services. *Journal of Air Transport Management*, 36, 110–119.

<https://doi.org/10.1016/j.jairtraman.2013.12.005>

Özcan, İ. Ç. (2014b). Economic contribution of essential air service flights on small and remote communities. *Journal of Air Transport Management*, 34, 24–29. <https://doi.org/10.1016/j.jairtraman.2013.07.005>

Palinkas, L., Aarons, G., Horwitz, S., Chamberlain, P., Hurlburt, M., & Landsverk, J. (2010). Mixed Method Designs in Implementation Research. *Administration and Policy in Mental Health*, 38, 44–53.

<https://doi.org/10.1007/s10488-010-0314-z>

Park, Y., & O'Kelly, M. E. (2017). Exploring accessibility from spatial interaction data: An evaluation of the Essential Air Service (EAS) program in the contiguous US air transport system. *Environment and Planning A: Economy and Space*, 49(4), 930–951.

<https://doi.org/10.1177/0308518X16680816>

Pinchemel, A., Caetano, M., Rossi, R., & Silva, M. (2022). Airline's business performance indicators and their impact on operational efficiency. *Brazilian Business Review*, 19(6), 642–665.

<https://doi.org/10.15728/bbr.2022.19.6.4.en>

Procolombia. (2024). *Mompox*. <https://colombia.travel/es/mompox>

Qualtrics. (2025). *Qualtrics XM - Experience Management Software* [Computer software]. <https://www.qualtrics.com/>

Rome2Rio. (2025). *De San Andrés a Isla de Providencia en 37 minutos: Precios y horarios para ir en Avión o Ferry*. Rome2Rio.  
<https://www.rome2rio.com>

Saaty, R. W. (1987). The analytic hierarchy process—What it is and how it is used. *Mathematical Modelling*, 9(3), 161–176.  
[https://doi.org/10.1016/0270-0255\(87\)90473-8](https://doi.org/10.1016/0270-0255(87)90473-8)

SATENA. (2025). *Satena Colombia | Vuela Con Satena | Mejor Cobertura Nacional*. <https://www.satena.com/>

Silva, C. J. L. E., Andrade, M. O. D., Falcao, V. A., & Silva, C. F. A. D. (2021). Subsidized Regional Airlines as a Sustainable Development Mechanism for Remote Locations Heavily Dependent on Air Transportation. *Journal of Sustainable Development*, 14(4), 108.  
<https://doi.org/10.5539/jsd.v14n4p108>

Sindhwani, R., Jayaram, J., & Ivanov, D. (2024). Meeting economic and social viability goals in regional airline schemes through hub-and-spoke network connectivity. *Annals of Operations Research*.  
<https://doi.org/10.1007/s10479-024-05858-0>

U. S. Government Accountability Office. (2019). *Commercial Aviation: Effects of Changes to the Essential Air Service Program, and Stakeholders' Views*

*on Benefits, Challenges, and Potential Reforms | U.S. GAO.*

<https://www.gao.gov/assets/gao-20-74.pdf>

Valdes, V., Corzo, O., & Canfield, C. (2024). Airport incentive regulation in practice. *Journal of Air Transport Management*, 117, 102590.

<https://doi.org/10.1016/j.jairtraman.2024.102590>

Warnock-Smith, D., Dziedzic, M., & Christidis, P. (2025). Assessing the impact of airport incentive schemes on regional air connectivity differentials across Europe. *Transport Policy*, 162, 106–112.

<https://doi.org/10.1016/j.tranpol.2024.11.022>

Whitaker, R. (2007). Validation examples of the Analytic Hierarchy Process and Analytic Network Process. *Mathematical and Computer Modelling*, 46(7), 840–859. <https://doi.org/10.1016/j.mcm.2007.03.018>

Williams, G., & Pagliari, R. (2004). A comparative analysis of the application and use of public service obligations in air transport within the EU. *Transport Policy*, 11(1), 55–66. [https://doi.org/10.1016/S0967-070X\(03\)00040-4](https://doi.org/10.1016/S0967-070X(03)00040-4)

Wittman, M. D. (2014). *An Assessment of Air Service Accessibility in U.S. Metropolitan Regions, 2007-2012.*

<https://dspace.mit.edu/handle/1721.1/87063>

Wittman, M. D., Allroggen, F., & Malina, R. (2016). Public service obligations for air transport in the United States and Europe: Connectivity effects and

value for money. *Transportation Research Part A: Policy and Practice*, 94, 112–128. <https://doi.org/10.1016/j.tra.2016.08.029>

World Bank Open Data. (2024). *GDP per capita, PPP (current international \$)—Colombia*. World Bank Open Data. <https://data.worldbank.org>

Wu, H., Hong Tsui, K. W., Ngo, T., & Lin, Y.-H. (2025). Investigating aviation subsidy scheme's impact on domestic aviation during the post-lockdown period: A case study of New Zealand. *Case Studies on Transport Policy*, 20, 101405. <https://doi.org/10.1016/j.cstp.2025.101405>

## Appendices

### Appendix A Ethical approval letter



26 June 2025

Dear Ms Saludes Clemente ,

Reference: CURES/25810/2025

Project ID: 29027

Title: Defining level of service standards for subsidised air transport in Colombia.

Thank you for your application to the Cranfield University Research Ethics System (CURES).

**We are pleased to inform you your CURES application, reference CURES/25810/2025 has been reviewed. You may now proceed with the research activities you have sought approval for.**

If you have any queries, please contact CURES Support.

We wish you every success with your project.

Regards,

CURES Team

## **Appendix B Questionnaires**

Appendix B contains the stakeholder and user questionnaires used in this study to evaluate the perceived importance of service variables and gather input for the classification framework.

### **B.1 SATENA user's questionnaire**

You are invited to take part in a research study conducted as part of my MSc in Air Transport Management at Cranfield University. As a user of SATENA's services in Colombia, your input is especially valuable to help understand and evaluate air connectivity in remote areas.

Researcher Contact Details:

Name: Ana Saludes Clemente

Student Number: 448745

Email: ana.saludesclemente@cranfield.ac.uk

The aim of this study is to develop a framework for evaluating the level of service of subsidised air transport routes in remote areas of Colombia. Your input will help identify key variables that influence service quality and guide future improvements.

The survey will take approximately 5-10 minutes to complete. Your participation is voluntary, and you may withdraw at any time.

By continuing, you confirm the following:

- I confirm that I have been informed about this research project and I agree to take part.
- I understand that all personal information I provide will be treated confidentially and my name will not be used in any report, publication, or presentation.
- I understand that I can withdraw from the project at any time by contacting the research team. I may also request withdrawal of my data up to 2 weeks after submitting the questionnaire, after which it will not be possible to identify my individual data from the anonymised results.
- I understand that the data I provide will be used by Cranfield University solely for research purposes. The data will be stored on the University's

secure network and will only be accessible by authorised users, in compliance with the UK Data Protection Act 2018.

- I confirm that I have read and understood the information provided above and give my consent to take part in this research.

Do you agree to participate under the terms described above?

- ☐ Yes, I agree to participate
- ☐ No, I do not agree to participate

In a country like Colombia, where geography often limits road access, SATENA provides a connecting service between communities and can facilitate mobility, access to services and regional integration. The following questions aim to gather perceptions of the service received during flight experiences with the airline. What is your main reason for travelling with SATENA? (Select one or more)

- ☐ Work
- ☐ Study
- ☐ Medical reasons
- ☐ Family visits
- ☐ Tourism
- ☐ Other \_\_\_\_\_

How frequently do you travel with SATENA?

- ☐ Weekly
- ☐ Monthly
- ☐ A few times per year
- ☐ Once per year or less
- ☐ Other \_\_\_\_\_

Which of these routes have you flown with SATENA? (Select all that apply)

- ☐ San Andrés - Providencia
- ☐ Medellín - Mompox
- ☐ Bogotá - Mitú
- ☐ Cali - Timbiquí
- ☐ Leticia - Tarapacá
- ☐ Other (Please write only one route. If you've flown more than one, choose the main one you want to give feedback about.)  
\_\_\_\_\_

*Display this question:*

*If Which of these routes have you flown with SATENA? (Select all that apply) = San Andrés - Providencia*

You are now answering questions about the route: San Andrés – Providencia.

How would you rate the number of flights offered per week?

- ☐ Too few
- ☐ Adequate
- ☐ More than enough
- ☐ Not sure

How would you describe the flight schedule (times of the day, connections)?

- ☐ Very convenient
- ☐ Acceptable
- ☐ Not convenient
- ☐ Not sure
- ☐ Other \_\_\_\_\_

Do you feel the service is reliable (on-time departures and arrivals)?

- ☐ Always
- ☐ Most of the time
- ☐ About half the time
- ☐ Sometimes
- ☐ Never

How affordable are the airfares for you?

- ☐ Very affordable
- ☐ Somewhat affordable
- ☐ Too expensive
- ☐ I don't pay for the ticket
- ☐ Other \_\_\_\_\_

Do you usually travel and return on the same day on this route?

- ☐ Yes, always
- ☐ Yes, sometimes
- ☐ No, never
- ☐ Not sure

The last five questions were asked separately for each of the five case study routes.

Now, the general accessibility and availability of alternative transport options across SATENA routes will be evaluated. How do you get to/from the airport at your destination?

- ☐ By road (private or public transport)
- ☐ By walking
- ☐ Boat
- ☐ Other \_\_\_\_\_

How long does it take you to reach the airport from your home?

- ☐ Less than 30 minutes
- ☐ 30 minutes to 1 hour
- ☐ 1 to 2 hours
- ☐ More than 2 hours

If air transport were not available, what would be your alternative?

- ☐ Boat
- ☐ Bus/road
- ☐ I wouldn't travel
- ☐ Other \_\_\_\_\_

Would you mind if flights to your destination included a stop before arrival? (*For example: A flight from Bogotá to Leticia that stops briefly in Florencia before continuing, without requiring a plane change.*)

- ☐ No, I wouldn't mind
- ☐ I wouldn't mind, as long as the stop is short
- ☐ Yes, I would prefer a non-stop flight
- ☐ Yes, I would avoid flights with stops whenever possible
- ☐ Not sure

Open suggestions (Optional)

What is the biggest challenge you face when flying with SATENA on this route?

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What improvements would you suggest for this service?

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## **B.2 Industry stakeholder's questionnaire**

You are invited to take part in a research study conducted as part of my MSc in Air Transport Management at Cranfield University.

Researcher Contact Details:

Name: Ana Saludes Clemente

Student Number: 448745

Email: ana.saludesclemente@cranfield.ac.uk

The aim of this study is to develop a framework for evaluating the level of service of subsidised air transport routes in remote areas of Colombia. Your input will help identify key variables that influence service quality and guide future improvements.

The survey will take approximately 5-10 minutes to complete. Your participation is voluntary, and you may withdraw at any time.

By continuing, you confirm the following:

- I confirm that I have been informed about this research project and I agree to take part.
- I understand that all personal information I provide will be treated confidentially and my name will not be used in any report, publication, or presentation.
- I understand that I can withdraw from the project at any time by contacting the research team. I may also request withdrawal of my data up to 2 weeks after submitting the questionnaire, after which it will not be possible to identify my individual data from the anonymised results.
- I understand that the data I provide will be used by Cranfield University solely for research purposes. The data will be stored on the University's secure network and will only be accessible by authorised users, in compliance with the UK Data Protection Act 2018.
- I confirm that I have read and understood the information provided above and give my consent to take part in this research.

Do you agree to participate under the terms described above?

- ☐ Yes, I agree to participate
- ☐ No, I do not agree to participate

Which organisation do you represent?

- ☐ Aerocivil
- ☐ Satena
- ☐ UPIT
- ☐ Academic
- ☐ Other \_\_\_\_\_

What is your role related to subsidised air transport? (Select all that apply)

- ☐ Route planning
- ☐ Policy and regulation
- ☐ Service performance monitoring
- ☐ Data analysis or reporting
- ☐ Strategic planning
- ☐ Finance
- ☐ Assessment of local transport needs
- ☐ Other \_\_\_\_\_

How important do you consider each of the following features when evaluating the quality of subsidised air services? (1 = Not Important, 5 = Very Important)

1      2      3      4      5

|                                           |                      |
|-------------------------------------------|----------------------|
| Frequency of flights (per week)           | <input type="text"/> |
| Schedule (time of day)                    | <input type="text"/> |
| Day-return possibility                    | <input type="text"/> |
| Total flight time                         | <input type="text"/> |
| Aircraft type (regional jet vs turboprop) | <input type="text"/> |

Within each category, which variable is more important? Choose one and indicate the strength. *This section uses a pairwise comparison method as part of a Multi-Criteria Decision-Making (MCDM) analysis (specifically, the Analytic Hierarchy Process – AHP). Please compare the two variables listed in each row:*

*Step 1: Select the variable you consider more important (column 1 or 2).*

*Step 2: Indicate how much more important it is by selecting a value from 1 to 9, where:*

- 1 = *Equal importance*
- 3 = *Moderate importance*
- 5 = *Strong importance*
- 7 = *Very strong importance*
- 9 = *Extreme importance*
- (2, 4, 6, 8 = *intermediate values*)

|                                                   | More important variable |   | Strength of importance |
|---------------------------------------------------|-------------------------|---|------------------------|
|                                                   | 1                       | 2 | (1-9)                  |
| 1. Weekly frequency vs 2. Schedule                | ○                       | ○ |                        |
| 1. Weekly frequency vs 2. Day-return possibility  | ○                       | ○ |                        |
| 1. Weekly frequency vs 2. Total flight time       | ○                       | ○ |                        |
| 1. Weekly frequency vs 2. Aircraft type           | ○                       | ○ |                        |
| 1. Schedule vs 2. Day-return possibility          | ○                       | ○ |                        |
| 1. Schedule vs 2. Total flight time               | ○                       | ○ |                        |
| 1. Schedule vs 2. Aircraft type                   | ○                       | ○ |                        |
| 1. Day-return possibility vs 2. Total flight time | ○                       | ○ |                        |
| 1. Day-return possibility vs 2. Aircraft type     | ○                       | ○ |                        |
| 1. Total flight time vs 2. Aircraft type          | ○                       | ○ |                        |

Which of the following subsidised routes are you familiar with? (*Familiarity means you have knowledge of the route's operations, community needs, or performance aspects.*)

- ☐ San Andrés - Providencia
- ☐ Medellín - Mompox
- ☐ Bogotá - Mitú
- ☐ Cali - Timbiquí
- ☐ Leticia - Tarapacá
- ☐ None of the above

Display this question:

*If Which of the following subsidised routes are you familiar with? (Familiarity means you have know... = San Andrés - Providencia (Islands)*

You are now answering questions about the route: San Andrés – Providencia

What is the minimum number of weekly flights that should be offered?

- ☐ 1 flight per week
- ☐ 2-3 flights per week
- ☐ 4-6 flights per week
- ☐ Daily flights (7 or more per week)

What would be an acceptable time of day for flights to depart on this route?

(You can choose more than one)

- ☐ Early morning (before 8:00 am)
- ☐ Mid-morning (8:00 am - 11:00 am)
- ☐ Midday to early afternoon (11:00 am - 3:00 pm)
- ☐ Late afternoon or evening (after 3:00 pm)

Should it be possible to make a round trip on the same day on this route?

- ☐ Yes, it should be possible every day of the week
- ☐ Yes, it should be possible a few days per week (2-3 times/week)
- ☐ Yes, but only occasionally (once a week or for specific needs)
- ☐ No, it's not necessary
- ☐ Not sure

The last three questions were asked separately for each of the five case study routes.

Do you have any additional comments, insights, or suggestions regarding subsidised air transport services or this questionnaire?

---

Would you be open to being contacted for a follow-up conversation (e.g. clarification or brief interview)?

- ☐ Yes, you may contact me
- ☐ No, I prefer not to be contacted further

*Display this question:*

*If Would you be open to being contacted for a follow-up conversation (e.g. clarification or brief in... = Yes, you may contact me*

Please provide your preferred contact information (Name and Email):

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