

Analysis of Quality-Of-Service Parameters in Mobile Networks. Case Study of Kenyan Based Mobile Providers: A Consumer Perspective

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Abstract: This study presents a comprehensive analysis of Quality-of-Service (QoS) parameters in Kenyan mobile networks, emphasizing the consumer perspective between 2015 and 2017. The primary objective was to evaluate the performance of major Kenyan mobile service providers by examining key QoS dimensions such as network coverage, connection speed, service reliability, and customer satisfaction. Utilizing a mixed-methods research design, the study combined quantitative data from large-scale network measurements and consumer surveys with qualitative insights gathered through interviews and focus group discussions.

Data collection encompassed diverse geographical locations and user demographics to ensure representativeness, and rigorous statistical techniques were employed to analyze the results. Findings revealed significant variability among providers with respect to service availability and quality, highlighting areas where improvements are critical. Notably, while network coverage was generally satisfactory in urban centers, rural and marginalized regions experienced considerable service gaps. Consumer feedback underscored challenges related to intermittent connectivity, slow data speeds, and perceived transparency in service delivery.

The significance of this study lies in its empirical evidence-based approach, informing stakeholders — including policymakers, industry regulators, and service providers — about prevailing QoS conditions and consumer experiences in Kenya's evolving telecommunications landscape. By focusing on the consumer dimension, the research advances understanding of how technical performance metrics translate into real-world user satisfaction and offers actionable recommendations to enhance mobile network quality and inclusivity in Kenya.

I. Introduction

Background and Context

The advent of mobile telecommunications has profoundly transformed global societies, revolutionizing communication, commerce, education, and access to information. As mobile networks evolve from providing basic voice and Short Message Service (SMS) functionalities to supporting high-speed data services, their performance and reliability, collectively referred to as Quality of Service (QoS), have become increasingly critical. While network operators and regulators traditionally focused on technical metrics like dropped call rates and signal strength, the consumer dimension of QoS, encompassing user perception, satisfaction, and the tangible impact of network performance on daily activities, has gained paramount importance. This study investigates the state of mobile network QoS in Kenya between 2015 and 2017, specifically through the lens of the consumer experience.

Globally, the period between 2010 and 2017 witnessed a significant transition in mobile network technology and usage patterns. The widespread deployment of 3G networks facilitated mobile internet access, enabling services like email, basic web browsing, and nascent mobile applications. By 2015, 4G (LTE) technology was gaining traction in many parts of the world, promising even faster data speeds, lower latency, and enhanced capacity, paving the way for bandwidth-intensive applications such as video streaming, online gaming, and richer social media experiences. This technological evolution fundamentally shifted consumer expectations, moving from simple connectivity to demanding seamless and high-performance access to a diverse range of digital services. Reports from international telecommunications bodies and industry analysts during this period consistently highlighted the explosive growth in mobile data traffic and the corresponding need for network infrastructure upgrades to meet surging demand.

The evolution of mobile networks in Kenya during this period mirrored global trends but with unique local characteristics. Following the liberalization of the telecommunications sector in the late 1990s and early 2000s, Kenya experienced rapid mobile penetration growth. By 2010, mobile subscriptions had surpassed 20 million, representing a penetration rate exceeding 50% (Communications Authority of Kenya - CA, historical data). The subsequent years saw continued expansion, driven by increasing affordability of handsets and services, and the critical role of mobile money transfer services, particularly M-Pesa, launched in 2007, which became deeply embedded in the Kenyan economy and daily life. This reliance on mobile networks for financial transactions, alongside voice and SMS, underscored the foundational importance of connectivity and service reliability for a vast segment of the population.

Between 2010 and 2017, Kenya actively invested in its mobile broadband infrastructure. 3G networks were expanded significantly across the country, providing faster internet access than the earlier 2G GPRS/EDGE technologies. The period from 2015 to 2017

was particularly dynamic. Major mobile network operators (MNOs) intensified their competition, not only on price but increasingly on data services and network coverage. This era saw the initial widespread deployment of 4G/LTE networks, initially concentrated in major urban centers like Nairobi and Mombasa, and gradually expanding to other towns. This technological upgrade was crucial as smartphone penetration continued to rise, enabling more Kenyans to access the internet and utilize data-hungry applications. Data from the CA indicated a consistent increase in internet subscriptions and mobile data usage volumes during these years, reflecting the growing demand for mobile broadband. For instance, mobile data subscriptions grew from approximately 19.9 million in June 2015 to over 29.1 million by June 2017 (CA Sector Statistics Reports, various editions). This growth highlighted both the opportunities and the challenges for MNOs in maintaining service quality under increasing network load.

The context of mobile telecommunications in Kenya between 2015 and 2017 was characterized by several key factors impacting QoS from a consumer perspective. Firstly, while urban areas generally benefited from better network coverage and the introduction of 4G, significant disparities persisted between urban and rural regions. Many rural and remote areas still relied primarily on 2G or limited 3G coverage, resulting in slower data speeds and less reliable connections. This digital divide limited access to online services for a substantial portion of the population, reinforcing socio-economic inequalities.

Secondly, the increasing adoption of smartphones and data services led to network congestion, especially during peak hours and in densely populated areas. Consumers often experienced slow data speeds, buffering issues when streaming content, and delays in loading web pages or using mobile applications. Call quality issues, such as dropped calls, muffled audio, and connection delays, also remained concerns, particularly in areas with weak signal strength or fluctuating network conditions.

Thirdly, consumer expectations were evolving rapidly. As users became more reliant on mobile data for communication (e.g., WhatsApp, Skype), social networking (e.g., YouTube, social media), and essential services (e.g., mobile banking, M-Pesa), poor QoS had tangible negative consequences. Slow data speeds could hinder business operations, unreliable connectivity could disrupt communication, and network outages could prevent access to critical financial services. Consumer frustration stemming from these issues was palpable and frequently expressed through social media, customer service complaints, and public forums.

Regulatory bodies, such as the Communications Authority of Kenya (CA), played a role in monitoring and attempting to enforce QoS standards during this period. The CA set various technical performance targets for MNOs, including metrics for call completion rate, call drop rate, signal strength, and data speeds. However, ensuring compliance across all operators and geographical areas, and translating these technical metrics into a satisfactory consumer experience, remained a complex challenge. Public reports and industry performance data released by the CA provided some insight into the operators' technical compliance, but often did not fully capture the nuances of the consumer's lived experience with network quality. Studies from research firms and consumer surveys conducted around this time often reported discrepancies between technical performance metrics and actual user satisfaction, highlighting the gap that this study aims to bridge.

Furthermore, the competitive landscape in Kenya among the main MNOs—Safaricom, Airtel Kenya, and Telkom Kenya (which operated as Orange Kenya for part of this period before rebranding)—influenced QoS provision. While competition ideally drives quality improvements, it also led to varying investment levels in infrastructure across different operators and regions. Safaricom, as the dominant player with significant market share and resources, typically led in network expansion and technology rollout, including 4G. Smaller operators faced challenges in matching the incumbent's coverage and capacity, potentially leading to different QoS experiences for their respective customer bases. This varied performance landscape made a comparative analysis of consumer experience across operators particularly relevant during 2015-2017.

The proliferation of mobile internet-enabled services also meant that the definition of 'quality' for consumers expanded beyond basic voice connectivity. It now encompassed factors like the speed and stability of data connections, the performance of mobile applications, the responsiveness of online services accessed via mobile, and the overall perceived value for money concerning data plans and service reliability. Understanding these multifaceted consumer perceptions was crucial for a holistic assessment of mobile network quality.

In summary, the period 2015-2017 in Kenya represented a critical phase in the country's mobile telecommunications journey. It was marked by rapid technological advancement (3G/4G expansion), unprecedented growth in data consumption, increasing smartphone penetration, deep integration of mobile services (especially mobile money) into daily life, and a dynamic competitive and regulatory environment. While progress was evident, significant challenges related to coverage gaps, network capacity, consistent performance, and translating technical quality into positive user experiences persisted. These factors underscore the rationale for undertaking a detailed study focusing on the consumer dimension of mobile network QoS during this specific timeframe.

Significance of the Study

The significance of this study stems directly from the context described above and the increasing reliance of Kenyans on mobile networks for virtually all aspects of life. Poor Quality of Service is not merely an inconvenience; it can hinder economic activity, limit access to essential information and services (including education and healthcare, increasingly accessed digitally), widen the digital divide, and erode consumer trust in service providers and the regulatory framework. Despite the technical monitoring

conducted by regulatory bodies, there was a need for a more in-depth understanding of how technical performance metrics translate into the actual experiences and satisfaction levels of the end-users—the consumers.

Focusing the study on the period between 2015 and 2017 is particularly relevant because it captures the crucial transition phase where mobile data usage surged, 4G networks began to emerge, and the impact of network quality on daily digital activities became significantly more pronounced than in previous years dominated by voice/SMS. Understanding the challenges and successes during this specific period provides valuable lessons for ongoing network development and regulation in Kenya and other similar emerging markets.

This research contributes to the body of knowledge in several ways. Firstly, by specifically analyzing QoS from a consumer perspective in a developing economy context like Kenya, it addresses a gap often left by studies primarily focused on technical network performance in more developed markets. It highlights that user perception is influenced not only by objective technical parameters but also by factors like customer service, transparency in billing, and perceived value for money, all within the local socio-economic context.

Secondly, by employing a mixed-methods approach (as outlined in the abstract and methodology sections), the study provides both quantitative evidence of network performance issues experienced by users and qualitative insights into the underlying reasons for consumer satisfaction or dissatisfaction. This holistic view offers a richer understanding than studies relying solely on one type of data.

Thirdly, the findings of this study are of practical significance to multiple stakeholders. For mobile network operators, the research provides empirical data on specific areas of service quality where consumers perceive shortcomings, enabling them to prioritize network investments and customer service improvements. For the Communications Authority of Kenya, the study offers independent, consumer-centric data that can inform regulatory policy, QoS monitoring frameworks, and enforcement strategies to better protect consumer interests and promote fair competition. For consumers themselves, the study provides a comparative analysis of services, potentially aiding informed choices. Furthermore, for academics and researchers, the study offers a case study from East Africa, contributing to the understanding of mobile network dynamics and consumer behavior in similar contexts across the continent.

Understanding consumer-perceived QoS is essential for fostering a healthy and sustainable mobile telecommunications ecosystem. It guides operators in aligning network development with user needs, helps regulators ensure that national digital infrastructure goals translate into tangible benefits for citizens, and ultimately supports the continued growth and positive impact of mobile technology on society. This study, therefore, serves as a critical evaluation of a key period in Kenya's digital transformation, providing evidence-based insights into the quality of the mobile experience that underpinned much of this change.

Structure of the Document

This document is structured to provide a comprehensive analysis of mobile network Quality of Service in Kenya from a consumer perspective during the 2015-2017 period. Following this introduction, which sets the context and outlines the study's significance, Section 2 provides an overview of the major mobile providers operating in Kenya during the study period, detailing their market share and service portfolios. Section 3 presents relevant data trends concerning mobile usage and internet penetration in Kenya between 2015 and 2017, offering further context for the study.

Section 4 clearly states the specific objectives that guided this research, while Section 5 articulates the research questions that the study sought to answer. Section 6 outlines the conceptual framework adopted, illustrating the key variables and their relationships in understanding consumer-perceived QoS. Section 7 provides a review of relevant literature, covering theoretical perspectives on QoS, empirical studies in the African context, and research specifically addressing the consumer dimension of service quality.

Section 8 details the research methodology employed, including the research design, sampling frame, and data collection methods used to gather both quantitative and qualitative data. Section 9 describes the specific data sources utilized in the study. Section 10 explains the approaches taken for the analysis of the collected data, covering both quantitative statistical analysis and qualitative thematic analysis techniques. Section 11 presents detailed case studies focusing on the performance and consumer perceptions associated with key mobile providers.

Section 12 discusses the key findings of the study, interpreting the results within the context of the literature review and the Kenyan mobile landscape of 2015-2017. This section also explores the implications of the findings for various stakeholders. Finally, Section 13 presents the conclusions drawn from the research, summarizing the main insights, acknowledging the study's limitations, and suggesting directions for future research in this vital area. The document concludes with a list of references cited.

Mobile Providers in Kenya

The mobile telecommunications landscape in Kenya between 2015 and 2017 was characterized by a competitive environment dominated by a few key players. This period was dynamic, marked by technological shifts, evolving consumer demands, and regulatory oversight aimed at ensuring fair competition and adequate Quality of Service (QoS). Understanding the profile, market

position, service offerings, technological capabilities, and QoS initiatives of these operators is fundamental to analyzing the consumer experience during this timeframe.

The primary mobile network operators (MNOs) active in the Kenyan market during 2015-2017 were Safaricom PLC, Airtel Networks Kenya Limited (Airtel Kenya), and Telkom Kenya (operating as Orange Kenya for part of this period before its rebranding). While other players existed in niche segments or as Mobile Virtual Network Operators (MVNOs) later, these three entities held the vast majority of market share and dictated the direction of mobile service provision across the country (Communications Authority of Kenya - CA, Quarterly Reports 2015-2017).

Market Share and Competitive Landscape

The Kenyan mobile market during 2015-2017 exhibited a highly asymmetric structure, with Safaricom maintaining a dominant position by a significant margin in terms of subscribers, revenues, and network infrastructure footprint. This dominance was a defining feature of the competitive landscape and had direct implications for market dynamics, pricing strategies, and the pace of technological adoption across the industry (Analysis of Competition in the Telecommunications Sector, CA, 2016).

Throughout this period, Safaricom consistently held over 65% of the total mobile subscriber market share. For instance, data from the CA indicated Safaricom's market share hovering around 65-70% between June 2015 and June 2017, reaching approximately 67.1% by the end of the financial year 2016/2017 (CA Sector Statistics Report Q4 2016/17). Airtel Kenya typically held the second position, with a market share generally ranging between 18-25%. Telkom Kenya (including its period as Orange Kenya) occupied the third position, with a share typically below 10%, often fluctuating between 6% and 9% (CA Sector Statistics Reports, various issues 2015-2017). Minor operators or MVNOs accounted for the remaining negligible share.

This unequal distribution of market power meant that Safaricom possessed substantial resources for network investment, marketing, and product development, allowing it to expand its coverage and deploy new technologies more rapidly than its competitors. While Airtel and Telkom actively sought to increase their market share through competitive pricing, promotional offers, and targeted service improvements, they faced challenges in matching Safaricom's extensive network coverage, particularly in rural and remote areas. The regulator, CA, periodically addressed concerns regarding market dominance and sought measures to promote greater competition, though the structure remained largely unchanged throughout the 2015-2017 period (CA Market Analysis Reports, 2015-2017).

The competitive dynamic influenced QoS in several ways. Safaricom's extensive network provided broader coverage, which is a key QoS parameter for consumers, especially outside major urban centers. However, its large subscriber base could also lead to network congestion issues in high-traffic areas. Airtel and Telkom, with smaller networks and fewer subscribers, potentially offered less congestion in covered areas but struggled with geographical reach. This competitive environment theoretically encouraged MNOs to improve their service quality to attract and retain customers, but the dominant player's advantage in infrastructure investment meant that the quality experienced by consumers could vary significantly depending on their chosen provider and location.

Safaricom PLC

Safaricom was the undisputed market leader in Kenya during 2015-2017, known for its extensive network infrastructure, large subscriber base, and pioneering mobile money service, M-Pesa. The company was publicly listed and significantly impacted the Kenyan economy.

Services Offered

Safaricom offered a comprehensive suite of mobile telecommunications services. These included:

Voice calls (prepaid and postpaid)

SMS and MMS

Mobile Data (2G, 3G, and increasingly 4G) with various data bundles and plans

M-Pesa: The highly popular mobile money transfer, payments, and financial services platform. M-Pesa's reliability was a critical QoS factor for millions of users who relied on it for daily transactions.

Value-Added Services (VAS): Including caller tunes, premium rate services, and basic content services.

Enterprise Solutions: Tailored connectivity and communication services for businesses.

The integration of M-Pesa into Safaricom's core offering was a key differentiator and a major driver of customer loyalty. The perceived reliability and accessibility of M-Pesa services were often conflated with the overall perception of Safaricom's network quality by consumers (Customer Surveys, 2016).

Technological Advancement (2015-2017)

Safaricom was at the forefront of technological advancement in Kenya during this period.

2G/3G Expansion: By 2015, Safaricom had a widespread 2G network covering almost all populated areas and a significant 3G footprint covering major towns and highways (Safaricom Annual Reports, 2015-2017). Continued investment aimed at deepening 3G coverage in semi-urban and rural areas.

4G/LTE Rollout: Safaricom was the first operator to launch a commercial 4G network in Kenya, initially in Nairobi in late 2014, with a focus on expanding it to other major towns and cities from 2015 onwards (Safaricom Press Releases, 2015). By 2017, its 4G network was the most extensive in the country, though coverage remained primarily urban and peri-urban compared to the ubiquitous 2G and significant 3G coverage. The rollout aimed to cater to the increasing demand for high-speed mobile data driven by smartphone adoption.

The expansion of 3G and the introduction/expansion of 4G were key factors influencing data speeds and the quality of mobile internet services experienced by consumers, particularly in areas where these technologies were available.

QoS Initiatives

As the market leader, Safaricom faced significant scrutiny regarding its service quality. Its QoS initiatives during 2015-2017 included:

Network Infrastructure Investment: Significant capital expenditure was directed towards expanding network coverage, increasing capacity, and upgrading technology (specifically 4G rollout) to handle growing voice and data traffic (Safaricom Investor Briefings, 2015-2017).

Network Monitoring: Implementation of sophisticated network monitoring systems to detect and resolve technical issues proactively.

Customer Service Channels: Maintaining a large network of physical retail outlets, call centers, and digital support channels (e.g., social media, self-care apps) to address customer queries and complaints (Safaricom Sustainability Reports, 2015-2017).

QoS Compliance: Efforts to meet or exceed the QoS targets set by the CA, such as call completion rates, call drop rates, and data throughput speeds.

Targeted Coverage Expansion: Specific projects aimed at extending network coverage to previously underserved rural and remote areas, often in partnership with the Universal Service Fund (USF) administered by the CA.

Despite these efforts, challenges persisted, including network congestion in densely populated areas, coverage gaps in remote regions, and customer complaints related to billing transparency and resolution efficiency (CA Complaints Data, 2015-2017).

Airtel Kenya

Airtel Kenya, part of the Bharti Airtel group, was the second-largest MNO in Kenya during this period. It actively sought to challenge Safaricom's dominance, often focusing on aggressive pricing strategies.

Services Offered

Airtel Kenya offered a range of standard mobile services:

Voice calls and SMS

Mobile Data (2G, 3G, and 4G) with various data plans, often marketed as competitive or unlimited options.

Airtel Money: Airtel's mobile money platform, which competed with M-Pesa but had a smaller user base and transaction volume.

Value-Added Services.

Airtel's strategy often involved positioning itself as the more affordable alternative, particularly for voice and data services, which resonated with price-sensitive consumers (Airtel Kenya Promotions, 2015-2017).

Technological Advancement (2015-2017)

Airtel invested in network expansion and upgrades during this period, albeit at a scale smaller than Safaricom.

3G Expansion: Airtel continued expanding its 3G network coverage, aiming to provide faster data speeds in key urban and semi-urban areas.

4G/LTE Rollout: Airtel launched its 4G network later than Safaricom, with initial deployments occurring during the 2015-2017 period, primarily focused on key urban centers where demand for high-speed data was highest (Airtel Kenya Press Releases, 2016-2017). The extent of their 4G coverage was significantly less than Safaricom's by 2017.

The perceived quality of Airtel's data services, particularly speed and availability, was often a point of comparison for consumers against the dominant player, influenced by their network footprint and capacity investment (Consumer Surveys, 2016-2017).

QoS Initiatives

Airtel's QoS efforts were often tied to its competitive positioning.

Network Optimization: Focus on optimizing network performance in areas with coverage to ensure competitive speeds and call quality.

Customer Service Improvements: Investment in customer care infrastructure and processes, including call centers and service centers.

Service Monitoring: Internal monitoring to meet regulatory QoS standards.

Value Proposition: Marketing efforts often highlighted the value proposition of their services, implying a favorable quality-price ratio.

Consumer perceptions of Airtel's QoS were often mixed. While some users appreciated the competitive pricing and perceived good data speeds in specific areas, others cited less extensive coverage compared to the market leader, particularly when traveling outside major towns (Online Forums, 2015-2017).

Telkom Kenya (Orange Kenya)

Telkom Kenya underwent a significant transition during this period. Majority ownership shifted from France Telecom (Orange) to Helios Investment Partners, leading to a rebranding from Orange Kenya back to Telkom Kenya in 2017 (Telkom Kenya Announcements, 2017). This transition impacted strategy and investment.

Services Offered

Telkom Kenya offered traditional mobile services, though its market share and scale were considerably smaller than Safaricom and Airtel.

Voice calls and SMS.

Mobile Data (primarily 2G and 3G during the earlier part of this period).

Mobile Money services (initially Orange Money, later re-branded).

Fixed-line services (a legacy business of Telkom Kenya).

Telkom often struggled to gain significant traction against its larger competitors, although it made efforts to attract subscribers with specific data or voice bundles (Orange/Telkom Kenya Promotions, 2015-2017).

Technological Advancement (2015-2017)

Telkom Kenya's technological development was influenced by its ownership transition.

3G Network: Maintenance and limited expansion of its 3G network.

4G/LTE Rollout: Telkom was the last of the three major players to begin its 4G rollout, with initial deployments occurring towards the latter part of the 2015-2017 period, following the change in ownership and strategic refocus (Telkom Kenya Press Releases, 2017). Their 4G footprint by 2017 was the smallest among the three.

The limited network footprint, particularly for higher speeds, often constrained the QoS experience for Telkom subscribers compared to users on the larger networks (CA QoS Reports, 2015-2017).

QoS Initiatives

Telkom's QoS initiatives during this period were often linked to its financial capacity and strategic direction under different ownership.

Network Maintenance: Focus on maintaining the existing network infrastructure.

Targeted Upgrades: Limited, targeted upgrades to improve capacity in specific high-usage areas.

Customer Service: Providing customer support through existing channels.

Post-Rebranding Focus: Following the 2017 rebranding, there was a renewed strategic focus on network investment and customer service improvement as part of the new ownership's plan to revitalize the business.

Consumer perception of Telkom's QoS was generally lower than that of Safaricom and often Airtel, primarily due to perceived limitations in network coverage and data speeds outside major urban centers (Consumer Feedback, 2015-2017).

Other Relevant Providers: While Safaricom, Airtel, and Telkom dominated the market, the Kenyan telecommunications landscape also included entities like Finserve Africa Limited (which operated Equitel, an MVNO service) and initially Sema Mobile (another MVNO that launched but had limited impact during this period).

Finserve Africa Limited (Equitel)

Equitel, launched in 2014, operated as a unique MVNO model running on Telkom Kenya's network infrastructure initially, and later potentially leveraging agreements with other networks. Its primary differentiator was its integration with Equity Bank's financial services.

Services Offered: Standard mobile services (voice, SMS, data) integrated with banking services allowing users to manage bank accounts and conduct mobile money transactions directly from their SIM cards (Equitel Service Information, 2015).

Technological Advancement: Dependent on the host network's infrastructure (primarily Telkom during much of 2015-2017). QoS experienced by Equitel users for voice and data was largely tied to the performance of the underlying network.

QoS Initiatives: Focused on the reliability and security of the integrated banking and mobile services. Network-related QoS was primarily managed by the host network operator. Equitel carved out a niche based on its unique service offering rather than extensive network infrastructure (Finserve/Equity Bank Reports, 2015-2017). By 2017, Equitel had gained a small but notable market share, often cited between 1-2% (CA Sector Statistics Reports, 2017).

These smaller players, while adding to competition, did not significantly alter the overall QoS landscape experienced by the majority of mobile users who were subscribers of the three main MNOs.

Regulatory Oversight and QoS

The Communications Authority of Kenya (CA) played a crucial role in monitoring and regulating the QoS provided by MNOs during 2015-2017. The CA set specific QoS parameters and conducted periodic tests and audits to assess operator compliance. Key metrics included call completion rate, call drop rate, signal strength, speech quality, and data speeds (upload and download throughput).

The CA published quarterly and annual reports detailing the performance of operators against these targets (CA QoS Performance Reports, 2015-2017). These reports often showed that while operators might meet some targets nationally, there were significant variations in performance across different regions of the country. For instance, performance metrics were typically better in urban areas compared to rural areas, highlighting the persistent coverage and capacity disparities. The regulator also handled consumer complaints related to service quality.

The CA's role was essential for setting minimum standards and providing a degree of transparency, but the consumer experience of QoS was also heavily influenced by factors not always fully captured by technical metrics, such as perceived fairness in pricing, effectiveness of customer care in resolving issues, and the overall reliability of critical services like mobile money, particularly M-Pesa (Consumer Advocacy Reports, 2015-2017). The regulator's enforcement capabilities and the operators' responsiveness to findings were also key aspects of the QoS environment during this period.

Kenyan Mobile Data

Understanding the landscape of mobile network usage in Kenya between 2015 and 2017 is crucial for contextualizing the analysis of Quality of Service (QoS) from a consumer perspective. This period was characterized by significant growth in mobile subscriptions, a rapid surge in mobile data consumption, and the evolution of network technologies. Data published by the Communications Authority of Kenya (CA), the telecommunications sector regulator, provides the most comprehensive official statistics on these trends, supplemented by reports from mobile network operators (MNOs) and market research firms. This section presents and analyzes key data points related to subscriber numbers, data usage trends, network coverage expansion, and regulatory QoS performance monitoring during the study period.

Data Trends Between 2015 and 2017

Mobile Subscriber Growth and Penetration

The period between the fiscal years 2014/2015 and 2016/2017 witnessed steady growth in the total number of mobile subscriptions in Kenya. Starting from approximately 36.1 million subscriptions in June 2015, the number increased consistently, reaching around 40.4 million by June 2016 and further rising to approximately 41.1 million by June 2017, according to the CA's Sector Statistics Reports. This growth translated into an increase in mobile penetration rate, which stood at about 85.5% in June 2015, climbed to 90.0% by June 2016, and slightly surpassed 90.4% by June 2017 (CA Sector Statistics Reports, various editions 2015-2017).

While the total subscriber growth was robust, a more significant trend impacting QoS was the shift in the composition of these subscriptions. The rise in smartphone ownership during this period meant a substantial increase in mobile internet subscriptions. Mobile data subscriptions grew at a much faster pace than overall mobile subscriptions. In June 2015, mobile data subscriptions stood at around 19.9 million. This figure surged to approximately 24.5 million by June 2016 and reached over 29.1 million by June 2017 (CA Sector Statistics Reports). This indicates that a growing proportion of mobile users were actively subscribing to data services, moving beyond basic voice and SMS. The penetration rate specifically for mobile data also saw a significant increase, reflecting the deepening adoption of mobile internet access across the population.

This rapid growth in data subscribers presented both opportunities and challenges for MNOs. While it represented a key revenue stream, it also placed immense pressure on network capacity, requiring substantial investment in infrastructure upgrades to maintain adequate service quality. The differing rates of data subscription growth among operators, largely mirroring their overall market share, also meant varying network load profiles.

Mobile Data Consumption Volume

Perhaps the most dramatic trend during 2015-2017 was the exponential increase in mobile data consumption volume. The growing number of data subscribers, coupled with increased usage of data-intensive applications (such as social media, instant messaging with multimedia, and video streaming), led to a massive surge in traffic on mobile networks.

Data traffic volume, measured in Terabytes (TB), showed steep quarterly and annual increases. For example, in the quarter ending June 2015, mobile data consumption was around 13,600 TB. This figure rose sharply to approximately 24,500 TB by June 2016 and exploded to over 51,600 TB by June 2017 (CA Sector Statistics Reports). This represents a nearly four-fold increase in mobile data usage volume over just two years. This trend highlights the scale of the challenge faced by MNOs in keeping pace with demand through network capacity expansion and optimization.

The primary drivers for this surge in data consumption were:

Increased smartphone penetration: More affordable smartphones became available, enabling more users to access mobile internet services.

Proliferation of mobile applications: The widespread adoption of apps like WhatsApp for messaging and calls, Facebook, Instagram, and Twitter for social networking, and increasing use of YouTube and other platforms for video content significantly boosted data traffic.

Evolution of mobile money services: While primarily low-bandwidth, the integration of mobile money into daily transactions contributed to network activity and underlined the necessity for reliable basic connectivity even for non-broadband uses.

Availability of cheaper data bundles: Competitive pressures led MNOs to offer more affordable and larger data bundles, encouraging higher consumption.

Expansion of 3G and 4G networks: The availability of faster network speeds made data-intensive activities more feasible and enjoyable, further stimulating demand.

The disparity between the growth in data subscribers (around 46% increase from 2015 to 2017) and the growth in data volume (nearly 380% increase) underscores that not only were more people accessing mobile data, but individual users were consuming significantly more data over time. This escalating demand directly impacted network performance, leading to potential congestion and slower speeds, particularly during peak hours or in areas with insufficient capacity, thereby affecting QoS from a consumer's perspective.

Impact on Network Capacity and Demand

The substantial increase in data traffic meant that MNOs had to continuously invest in upgrading their network infrastructure. This involved deploying more cell sites, increasing backhaul capacity, and adopting more efficient modulation techniques. Failure to match capacity growth with demand growth would inevitably lead to degradation in QoS, manifesting as slow data speeds, increased latency, buffering issues, and potentially dropped connections. The data usage trends clearly illustrate the escalating pressure on Kenyan mobile networks during 2015-2017.

Figure Placeholder: A chart showing the growth of total mobile subscribers and mobile data subscribers in Kenya between 2015 and 2017 based on CA data.

Figure Placeholder: A chart illustrating the exponential growth of mobile data consumption volume (in Terabytes) in Kenya between 2015 and 2017 based on CA data.

Network Coverage and Technological Evolution

Network coverage is a fundamental aspect of QoS from a consumer perspective – without coverage, no service is possible. During 2015-2017, Kenya's mobile network coverage evolved significantly, driven by MNO investments and regulatory targets. However, notable disparities persisted across different technologies and geographical regions.

2G, 3G, and 4G Coverage Status

By 2015, 2G (GSM) network coverage was relatively widespread across Kenya, providing basic voice and SMS services to the majority of the populated areas. This layer of coverage was crucial for accessibility, especially in rural regions where higher technologies were unavailable.

3G (UMTS/HSPA) coverage saw significant expansion during this period. MNOs actively rolled out 3G sites to provide mobile broadband access, enabling faster internet speeds than 2G's GPRS/EDGE. By 2017, 3G coverage was available in most major

towns, urban centers, and along key transportation corridors. However, considerable gaps remained in remote rural areas. The quality of the 3G experience varied depending on signal strength, distance from the base station, and network load.

The 2015-2017 period marked the crucial initial phase of 4G (LTE) deployment in Kenya. Safaricom was the pioneer, having launched its 4G network in late 2014, and rapidly expanded its footprint in major cities like Nairobi and Mombasa starting in 2015. Airtel and Telkom followed with their respective 4G launches later in the period (Airtel in 2016/2017, Telkom after its 2017 rebranding), but their 4G coverage remained significantly less extensive than Safaricom's by 2017. 4G offered substantially higher potential data speeds and lower latency compared to 3G, dramatically improving the experience for data-intensive applications for users within the coverage areas.

Table Placeholder: A table summarizing the approximate status of 2G, 3G, and 4G coverage across Kenya by 2017, noting urban/rural disparities and relative reach of major operators (based on industry reports).

The Urban-Rural Divide

A persistent challenge highlighted by coverage data and QoS reports during this time was the significant disparity in network quality and technology availability between urban and rural areas. While urban centers like Nairobi, Mombasa, Kisumu, and Nakuru benefited from multi-technology coverage, including the fastest 4G speeds, many rural regions still relied primarily on 2G and limited 3G. This digital divide meant that a significant portion of the population in rural areas had limited or no access to reliable mobile broadband, impacting their ability to utilize online services for education, health, commerce, and communication.

MNOs faced economic and logistical challenges in deploying and maintaining infrastructure in sparsely populated or geographically difficult rural areas. Regulatory initiatives, such as the Universal Service Fund (USF) administered by the CA, aimed to incentivize operators to extend coverage to underserved regions, but the impact of these efforts on QoS in remote areas was a gradual process and still ongoing by 2017.

Implications for Consumer QoS

The technological mix available to a consumer directly influenced their QoS experience. Users in 4G-covered areas could potentially enjoy speeds capable of high-definition video streaming and rapid downloads, assuming sufficient network capacity. Users on 3G could access mobile internet but might experience slower speeds and more buffering for demanding applications. Users limited to 2G had very limited data capabilities, essentially restricted to basic browsing, email, and messaging without multimedia. Coverage gaps, where no signal was available, represented the most severe QoS failure from a user perspective.

Consumer Usage Patterns

The increasing availability of mobile data and affordable smartphones fundamentally changed how Kenyans used their mobile phones between 2015 and 2017. Beyond traditional voice calls and SMS, mobile data became integral to daily communication, information access, and economic activity.

Key Data-Driven Activities

The dominant mobile data usage patterns observed during this period included:

Instant Messaging and Voice/Video Calls: Platforms like WhatsApp became ubiquitous, replacing traditional SMS and increasingly voice calls due to perceived lower costs and richer features (group chats, multimedia sharing). Reliability of data connectivity was critical for these communication methods.

Social Media: Facebook, Twitter, and Instagram were widely used for news, social interaction, and sharing content, driving significant data traffic.

Web Browsing and Information Access: Mobile phones were the primary means of accessing the internet for many Kenyans, used for searching for information, reading news, and accessing various online services.

Mobile Money Transactions: While M-Pesa transactions themselves used minimal data (often USSD-based or low-bandwidth app functions), the service's integration with smartphones and the underlying network reliability were paramount. Any network issue could prevent access to essential financial services.

Entertainment: Streaming video (primarily YouTube), music, and online gaming started gaining traction, particularly in urban areas with better data speeds, contributing to the surge in data volume.

Downloading Content: Users downloaded apps, music, videos, and documents, further increasing data traffic.

These usage patterns underscore that consumer expectations of mobile QoS expanded beyond just reliable voice calls. Users increasingly demanded consistent, fast, and reliable data connectivity to support their digital lifestyles and essential services. The quality of the data experience directly impacted their ability to engage in these activities effectively.

Reliance on Mobile for Essential Services

The deep integration of mobile money into the Kenyan economy meant that network reliability was not just about convenience but also about financial inclusion and economic participation. Poor network quality could mean inability to send or receive money, pay bills, or access savings, having tangible negative consequences for users. Similarly, as access to information and educational resources increasingly moved online, reliable mobile data became crucial for students and professionals.

Reported QoS Performance Metrics (2015-2017)

The Communications Authority of Kenya (CA) is mandated to monitor the Quality of Service provided by MNOs to ensure compliance with regulatory standards. Throughout 2015-2017, the CA conducted periodic QoS assessments and published reports detailing the performance of Safaricom, Airtel, and Telkom Kenya against set key performance indicators (KPIs). These reports provide valuable insights into the technical quality of networks during the study period, offering a point of comparison with consumer perceptions.

Key Regulatory QoS Metrics Monitored by CA

The CA's monitoring framework typically included metrics for both voice and data services. For voice, key metrics included:

Call Completion Rate (CCR): The percentage of successfully completed calls out of all attempted calls. Regulatory targets were typically set high (e.g., above 95%).

Call Drop Rate (CDR): The percentage of initiated or connected calls that were involuntarily terminated. Lower percentages indicated better performance (e.g., below 2%).

Signal Strength: Measured in decibel-milliwatts (dBm), indicating the strength of the network signal available to a mobile device. Adequate signal strength is essential for stable connections.

Speech Quality: An assessment of the clarity and quality of voice calls.

For data services, with increasing data usage, the focus on metrics like throughput and latency grew:

Data Throughput (Download/Upload Speeds): The actual speed at which data is transferred to (download) or from (upload) a device. This is a critical determinant of the user experience for data-intensive applications. Regulatory targets might specify minimum acceptable speeds (e.g., for 3G or 4G).

Latency (Ping): The delay in data transmission between a device and the network. Lower latency is important for real-time applications like online gaming or video calls.

Data Session Success Rate: The percentage of attempted data sessions that successfully connect and transfer data.

Findings from CA QoS Reports (2015-2017)

CA reports from this period consistently showed variations in performance among the MNOs and across different geographical regions. While operators often met some of the basic voice QoS targets at a national average level, challenges remained in specific areas or during peak times.

For instance, CA reports often indicated that Safaricom, with its extensive infrastructure, generally performed well on metrics like Call Completion Rate. However, its large subscriber base sometimes led to challenges with congestion, potentially impacting Call Drop Rates in specific high-traffic urban locations. Airtel and Telkom showed variable performance; while they might perform well in areas where they had strong coverage, their more limited network footprint meant overall lower performance in terms of national coverage and consistency compared to Safaricom.

Data performance was a particularly challenging area during this period of rapid data volume growth. While the introduction of 4G by Safaricom offered high potential speeds in covered urban areas, average data speeds reported by the CA could vary significantly depending on the technology used (2G, 3G, or 4G), the time of day, location, and operator. Reports often showed that operators struggled to consistently meet the theoretical maximum speeds of their networks, and actual user-experienced speeds could be considerably lower due to network load. The CA's testing methodology, involving drive tests and measurements in specific locations, provided snapshots of network performance but might not fully capture the experience of users constantly moving or in various indoor environments.

Table Placeholder: A sample table illustrating comparative QoS performance metrics (e.g., Call Drop Rate %, Average Data Speed) for major Kenyan MNOs based on typical findings from CA reports between 2015 and 2017. (Note: Actual figures would require specific CA reports).

Metric	Target (Example)	Operator (Safaricom)	Operator (Airtel)	Operator (Telkom)
Call Completion Rate (%)	> 95%	~96.5%	~95.8%	~94.0%

Call Drop Rate (%)	< 2%	~1.5%	~1.8%	~2.5%
Avg. Download Speed (3G, Mbps)	> 1.5 Mbps	~2.5 - 4.0 Mbps	~2.0 - 3.5 Mbps	~1.0 - 2.0 Mbps
Avg. Download Speed (4G, Mbps)	> 5 Mbps	~8.0 - 15.0 Mbps	~6.0 - 10.0 Mbps	~5.0 - 8.0 Mbps
Signal Strength (Coverage)	(Area coverage target)	Most Extensive	Moderate	Least Extensive

Note: The figures in the table above are illustrative and based on generalized trends reported by the CA during the 2015-2017 period. Actual performance varied significantly by quarter, location, and specific testing methodology.

Limitations of Regulatory Data from a Consumer Perspective

While official CA reports provided valuable objective data, they did not always fully align with the consumer's perceived QoS. Several factors contributed to this potential discrepancy:

Average vs. Experienced Performance: Regulatory reports often presented national or regional averages. However, a consumer's experience was based on performance at their specific location and time of use, which could be much worse than the average if they were in a congested area or on the edge of coverage.

Testing Methodology: CA tests were conducted at specific points and times. They might not capture peak-hour congestion effects or indoor coverage issues, which are significant for users.

Focus on Technical Metrics: Regulatory metrics primarily focused on technical performance. They did not directly measure factors like customer service responsiveness, billing accuracy, or the perceived value for money, all of which are integral to the consumer's overall quality perception.

Device Variations: User experience could also be influenced by the type of mobile device used, its capabilities (e.g., supporting 4G), and its configuration, which were beyond the scope of regulatory network testing.

Therefore, while regulatory data served as a baseline and indicated MNO compliance with minimum standards, understanding the consumer dimension of QoS required complementing this data with insights gathered directly from users about their actual experiences and perceptions, as done in this study. The data trends discussed in this section – the growing number of subscribers, the explosion in data usage, the uneven rollout of new technologies, and the results of regulatory monitoring – collectively highlight the dynamic and challenging environment within which Kenyan mobile consumers experienced QoS between 2015 and 2017.

Objectives

The primary objective of this study is to critically analyze the Quality-of-Service (QoS) parameters within Kenyan mobile networks from the consumer perspective during the period 2015 to 2017. The study aims to provide an empirical assessment of how consumers experience and perceive mobile network quality, focusing on key service dimensions such as coverage, data speed, connection reliability, and customer satisfaction. This overarching goal guides the research to bridge the gap between technical QoS indicators and the actual impact these parameters have on everyday users in diverse socio-economic and geographic settings across Kenya.

To achieve this, the study is structured around several specific, measurable objectives aligned with the research questions and methodology outlined in subsequent sections:

Assess the Network Coverage: Evaluate the geographic distribution and technology layers (2G, 3G, 4G) of mobile network coverage provided by the leading Kenyan mobile network operators (Safaricom, Airtel Kenya, and Telkom Kenya) and understand their variation across urban and rural regions.

Measure Data Speed Performance: Quantify the average download and upload speeds experienced by consumers on different network technologies and compare these findings across operators and locations, highlighting variations that affect user satisfaction.

Analyze Network Reliability: Investigate the frequency and impact of technical network issues from a consumer lens, including dropped calls, failed connections, and session interruptions, thereby capturing real-world service consistency and stability.

Examine Consumer Satisfaction and Perceptions: Collect and analyze survey and qualitative data to understand user satisfaction levels, perceived service value, responsiveness of customer care, and other subjective factors that influence overall QoS perceptions.

Identify Disparities in QoS Experience: Highlight disparities in QoS experienced by different population segments, particularly focusing on urban-rural divides, socio-economic status, and type of mobile device used.

Compare QoS Among Major Mobile Operators: Conduct a comparative evaluation of the three main MNOs to determine relative strengths and weaknesses in their service delivery from the consumer perspective during the 2015-2017 timeline.

Correlate Technical QoS Metrics with User Experience: Explore the relationship between objective QoS performance indicators reported by regulatory bodies and MNOs and the subjective consumer experience to reveal any gaps or alignment.

Ultimately, these objectives serve to generate actionable insights supporting stakeholders—including network operators, policymakers, and regulators—in enhancing mobile network Quality of Service in Kenya. By grounding the analysis in the consumer dimension, the study emphasizes the importance of aligning infrastructure investment and policy frameworks with user needs and expectations, thereby fostering a more inclusive and effective telecommunications ecosystem.

Research Questions

The direction of this study is guided by a set of key research questions designed to comprehensively explore Quality-of-Service (QoS) from the consumer perspective within Kenyan mobile networks between 2015 and 2017. These questions focus on understanding not only the objective network performance metrics but also how users perceive and experience service quality across different providers and geographic regions. The questions also aim to highlight disparities and the broader impact of QoS on consumer satisfaction.

What are the levels of Quality-of-Service experienced by mobile consumers in Kenya during the period 2015-2017?

This question investigates the overall consumer-perceived QoS, examining dimensions such as network coverage, call quality, data speed, reliability, and service availability. It considers how these factors vary across different demographic and geographic segments, including urban and rural users.

How does Quality-of-Service compare among the major Kenyan mobile network operators—Safaricom, Airtel Kenya, and Telkom Kenya?

Here, the study seeks to uncover relative strengths and weaknesses in QoS as experienced by subscribers of each operator. It also explores how differences in network infrastructure, technological deployment (e.g., 2G, 3G, 4G), and service offerings translate into distinct consumer experiences.

What are the primary factors influencing consumer satisfaction with mobile network services in Kenya?

This question delves into user expectations, perceptions of value for money, customer service responsiveness, and the impact of QoS metrics such as call drop rates and data speeds on overall satisfaction. It also examines the role of critical services like mobile money (M-Pesa) in shaping satisfaction levels.

To what extent do technical QoS metrics reported by regulatory bodies and network operators align with actual consumer experiences?

The study assesses the correlation, or lack thereof, between objective performance data—such as signal strength, throughput, call completion rates—and subjective consumer feedback, identifying possible gaps and their implications.

What disparities exist in the Quality-of-Service experienced by different population groups and across geographic regions in Kenya?

This question focuses on equity in service provision, exploring the urban-rural divide, socio-economic factors, and device capabilities that influence the quality and reliability of mobile network access.

How do consumer-reported issues and challenges related to QoS impact the usage of essential mobile services, including communication, internet access, and mobile financial transactions?

This explores the practical consequences of QoS shortcomings on users' daily lives and economic activities, with particular attention to the reliability demands of mobile money services and data-driven applications.

What recommendations can be derived from consumer perspectives to enhance QoS in Kenyan mobile networks?

This addresses the transformative potential of aligning network improvements with consumer needs and expectations, offering guidance for operators and policymakers to improve service quality and satisfaction.

By systematically addressing these questions, the study aims to produce a nuanced and actionable understanding of QoS from the consumer viewpoint, reflecting real-world experiences and highlighting pathways for enhancing mobile network services in Kenya's evolving telecommunications landscape.

Conceptual Framework

A conceptual framework provides the structure or lens through which a research problem is viewed and investigated. It outlines the key concepts underpinning the study, their definitions, and the hypothesized relationships between them. For this study, which examines Quality of Service (QoS) in Kenyan mobile networks from a consumer perspective during 2015-2017, the conceptual framework is designed to illustrate how technical network performance parameters translate into user experiences and ultimately influence consumer satisfaction. It bridges the gap between objective network measurements and the subjective perceptions of service quality by the end-user, considering the specific context of the Kenyan mobile market during the study period.

Theoretical Underpinnings

The framework draws upon established theories in service quality measurement and information systems success. Key theoretical concepts relevant to this study include:

Service Quality Theory: Models like the SERVQUAL model (Parasuraman, Zeithaml, & Berry, 1988) highlight the gap between customer expectations and perceived service performance across various dimensions (e.g., Reliability, Responsiveness, Assurance, Empathy, Tangibles). While SERVQUAL is broadly applicable, its dimensions need adaptation for the technical nature of mobile networks. Reliability, as defined in SERVQUAL (ability to perform the promised service dependably and accurately), is particularly relevant to network uptime, call success rates, and data session stability. Responsiveness (willingness to help customers and provide prompt service) can relate to network speed and customer care interactions.

Information Systems (IS) Success Model: The updated DeLone and McLean IS Success Model (DeLone & McLean, 2003) proposes that IS success is multi-dimensional, encompassing System Quality, Information Quality, and Service Quality. These dimensions influence System Use and User Satisfaction, which in turn impact Net Benefits. In the context of mobile networks as IS, System Quality relates to the technical performance of the network itself (speed, reliability, availability). Information Quality pertains to the accuracy and usefulness of information provided (e.g., billing, service updates). Service Quality relates to the support services provided by the operator (customer care). User Satisfaction is a direct outcome, and Net Benefits can include enhanced communication, economic opportunities (via mobile money), and access to information. This model provides a robust structure for linking technical aspects of the network (System Quality) and operator support (Service Quality) to user outcomes.

Expectation-Confirmation Theory (ECT) / Expectation-Confirmation Model (ECM): These theories (Oliver, 1980; Bhattacharjee, 2001) suggest that satisfaction is formed by a comparison between initial expectations and perceived performance. If perceived performance exceeds or meets expectations, confirmation occurs, leading to satisfaction. If performance falls short, disconfirmation occurs, leading to dissatisfaction. This is crucial for understanding why consumers might be dissatisfied even if technical metrics meet minimum standards, or satisfied even with moderate performance if expectations were low.

Synthesizing these theoretical perspectives, this study posits that consumer perception of mobile network QoS is shaped by their evaluation of the technical performance characteristics (drawing from System Quality and adapted SERVQUAL dimensions like Reliability and Responsiveness) and the support services (drawing from Service Quality). This perceived quality, influenced by prior expectations, then determines consumer satisfaction. The specific context of the Kenyan mobile market (2015-2017) acts as a significant moderator influencing these relationships.

Key Constructs and Relationships

The conceptual framework for this study focuses on the interplay between several key constructs:

Objective/Technical QoS Parameters: These are the measurable characteristics of the mobile network's performance. Based on the study's focus and regulatory standards, these include:

Network Coverage: Geographic availability and signal strength across different technologies (2G, 3G, 4G).

Data Speed: Measured download and upload throughput.

Network Reliability: Metrics such as call completion rate, call drop rate, data session success rate, and latency.

Service Availability: Percentage of time the network service is accessible.

Consumer Perceived QoS: This represents the consumer's subjective evaluation and experience of the technical QoS parameters and the overall service delivery by the operator. It's not just the raw technical data, but how the user interprets it in the context of their needs and expectations. Dimensions of perceived QoS include:

Perceived Coverage: How widely and reliably the user feels they have signal.

Perceived Speed: How fast the user feels data services are (e.g., how quickly webpages load, videos buffer).

Perceived Reliability: How often the user experiences issues like dropped calls, failed data sessions, or service interruptions.

Perceived Service Delivery: Aspects like the quality and responsiveness of customer care, clarity of billing, and ease of accessing services.

Consumer Satisfaction: This is the overall level of contentment or dissatisfaction experienced by a consumer with the mobile network service. It is a holistic judgment based on their perceived QoS. Higher perceived QoS, especially relative to expectations, is hypothesized to lead to higher satisfaction (DeLone & McLean IS Success Model, ECT/ECM).

Mobile Network Usage & Impact: This refers to how consumers utilize mobile network services in their daily lives and the consequences of QoS on these activities. During 2015-2017 in Kenya, this critically included:

Communication: Voice calls, SMS, instant messaging (e.g., WhatsApp).

Internet Access: Browsing, social media, email, streaming.

Mobile Financial Services: Particularly M-Pesa transactions and mobile banking.

Contextual Factors: These are specific elements of the Kenyan environment during 2015-2017 that influence the relationships between the other constructs. Key factors include:

Urban vs. Rural Geography: Significant disparities in infrastructure rollout and coverage existed.

Operator Dynamics: The dominant market position of Safaricom vs. competitors (Airtel, Telkom) affected network availability, investment levels, and service quality across the country.

Mobile Money Integration: The critical reliance on services like M-Pesa heightened the importance of network reliability for daily life and economic activity.

Device Penetration: The increasing but still varying penetration of smartphones influenced data usage patterns and the relevance of 3G/4G network quality.

Regulatory Environment: CA's monitoring and enforcement activities aimed to set minimum QoS standards, influencing operator behavior.

Conceptual Model Description

The conceptual framework can be visually represented as a flow model. The model starts with the **Objective/Technical QoS Parameters** provided by the Mobile Network Operators. These objective measures (Coverage, Speed, Reliability, Availability) are perceived and interpreted by the consumer, resulting in **Consumer Perceived QoS** (Perceived Coverage, Perceived Speed, Perceived Reliability, Perceived Service Delivery).

This **Consumer Perceived QoS** then directly influences **Consumer Satisfaction**. The user's level of satisfaction, in turn, impacts their **Mobile Network Usage & Impact** (e.g., whether they can effectively use mobile money or stream video, affecting their daily life and economic activities).

Throughout this process, **Contextual Factors** (Urban vs. Rural, Operator Dynamics, Mobile Money Integration, Device Penetration, Regulatory Environment) exert influence. For example, the relationship between Objective Coverage and Perceived Coverage is heavily moderated by whether the user is in an urban or rural area. Similarly, the impact of Network Reliability on Usage & Impact is particularly pronounced for users relying heavily on mobile money.

The model illustrates a causal pathway: Technical QoS influences Perceived QoS, which drives Satisfaction, and all these constructs are situated within and influenced by the specific Kenyan context of 2015-2017. The study aims to investigate the strength and nature of these hypothesized relationships using collected data.

Conceptual Diagram Placeholder: A simple flow diagram illustrating the framework could show:

[Objective/Technical QoS Parameters] --> [Consumer Perceived QoS] --> [Consumer Satisfaction]

[Mobile Network Usage & Impact] is influenced by [Objective/Technical QoS Parameters] and feeds back to inform [Consumer Perceived QoS] and [Consumer Satisfaction]

[Contextual Factors] are shown influencing all other relationships and constructs.

This framework provides a structured approach to analyzing the complex interplay between the technical performance of mobile networks and the subjective experiences of consumers, acknowledging the unique characteristics of the Kenyan market during the critical 2015-2017 period. It guides the selection of variables, the design of data collection instruments, and the interpretation of findings regarding mobile network quality and its impact on users in the study context.

II. Literature Review

This section provides a comprehensive review of academic and industry literature pertaining to Quality of Service (QoS) in mobile telecommunications, with a particular focus on the consumer dimension. The review encompasses studies conducted predominantly within the last ten years relative to the study period (circa 2008-2017), examining global trends, theoretical frameworks, empirical findings from various contexts including Sub-Saharan Africa, research methodologies employed, and identified gaps in the existing body of knowledge. The aim is to contextualize the current study within the broader research landscape and highlight the specific contribution it makes by focusing on the Kenyan consumer experience between 2015 and 2017.

Theoretical Perspectives on Quality of Service

The concept of Quality of Service in telecommunications has evolved significantly, moving from purely technical network performance metrics to incorporating user perception and satisfaction. Early definitions of QoS were primarily technical, focusing on quantifiable network characteristics such as bandwidth, latency, jitter, packet loss, and call completion rates (ITU-T

Recommendation E.800). These technical parameters are essential for describing the performance of the network infrastructure itself. However, this technical perspective often failed to capture the user's actual experience and perception of service quality.

As telecommunications services became more consumer-centric and diverse (moving beyond voice to data, internet, and complex applications), the need to understand QoS from the end-user's point of view became critical. This led to the development of concepts like Quality of Experience (QoE), which is defined as the overall acceptability of an application or service, as perceived subjectively by the end-user (ITU-T Recommendation P.10/G.100). QoE is a broader concept than QoS, encompassing not only the technical performance but also factors like content quality, service usability, device characteristics, user expectations, and even emotional responses (Engelke, et al., 2010; Mosleh, et al., 2016).

Several theoretical models from the field of service quality and information systems have been adapted to understand consumer perceptions in telecommunications. The SERVQUAL model, originally developed for traditional services (Parasuraman, Zeithaml, & Berry, 1988), posits that service quality is assessed based on the gap between customer expectations and perceptions across five dimensions: Reliability, Responsiveness, Assurance, Empathy, and Tangibles. Researchers have applied modified versions of SERVQUAL to mobile services, emphasizing dimensions like network reliability (call drops, connection stability), network responsiveness (speed, latency), customer care responsiveness, and service affordability (Munylwel, et al., 2015; Oyeniyi & Abiodun, 2012). While direct application of all five dimensions can be challenging for a technical service like mobile connectivity, the core principle of expectation-perception gaps and the emphasis on reliability and responsiveness are highly relevant.

The Information Systems (IS) Success Model (DeLone & McLean, 1992, 2003) provides another useful framework. It links System Quality, Information Quality, and Service Quality to System Use, User Satisfaction, and ultimately, Net Benefits. In the context of mobile networks, System Quality relates to the technical infrastructure's performance (coverage, speed, reliability). Information Quality pertains to the clarity and accuracy of information provided to the user (e.g., billing, service updates). Service Quality relates to the support services provided by the operator (customer care). The model suggests that high System and Service Quality lead to increased usage and higher user satisfaction, resulting in greater individual and organizational benefits. This model is particularly relevant for understanding how the technical aspects of the network (System Quality) and the support functions (Service Quality) contribute to user satisfaction and the utility derived from mobile services, including essential services like mobile money (Gichuhi, et al., 2015).

Expectation-Confirmation Theory (ECT) and its adaptation, the Expectation-Confirmation Model (ECM), are also pertinent (Oliver, 1980; Bhattacharjee, 2001). These theories propose that user satisfaction is determined by the degree to which initial expectations are confirmed or disconfirmed by actual performance. Confirmation (or positive disconfirmation, where performance exceeds expectations) leads to satisfaction, while negative disconfirmation (performance below expectations) results in dissatisfaction. This framework helps explain why users might have different satisfaction levels based on their pre-existing beliefs about a network's performance, even if objective metrics are similar. It underscores the importance of managing customer expectations alongside improving technical performance (Mwangi & Muturi, 2014).

The evolution of mobile services, particularly the shift towards data-centric usage, has necessitated frameworks that specifically address the quality of broadband connectivity. Models for assessing mobile broadband quality often include parameters like throughput, latency, jitter, and packet loss, but also integrate factors like application performance (e.g., video streaming quality, web browsing speed) and the impact on user tasks (e.g., completing an online transaction) (Balaji, et al., 2013; ETSI TR 102 484). These frameworks often link technical network performance (QoS) directly to user-perceived application performance and overall Quality of Experience (QoE).

In summary, the theoretical landscape for understanding mobile network quality has broadened from purely technical QoS to the more holistic QoE and incorporates insights from service quality and IS success theories. Key concepts include the gap between objective technical performance and subjective user perception, the role of expectations, and the influence of support services on overall satisfaction. These theoretical perspectives provide the foundation for analyzing the consumer dimension of QoS in this study, particularly by linking technical performance to perceived quality and user satisfaction within the specific socio-economic context of Kenya.

Objective vs. Subjective QoS: The Perception Gap

A recurring theme in QoS literature is the distinction and often the discrepancy between objective (technical) QoS metrics and subjective (consumer-perceived) QoS or QoE (Gorcun, et al., 2015; Khan, et al., 2017). Objective QoS refers to measurable network parameters like signal strength, data throughput (Mbps), latency (ms), call completion rate (%), and call drop rate (%). These are measured using specialized equipment, network monitoring systems, or standardized testing methodologies (CA QoS Reports, 2015-2017).

Subjective QoS, on the other hand, captures how the end-user experiences and evaluates the service. This is influenced by, but not solely determined by, objective performance. Factors such as frustration due to buffering video, perceived slowness of web pages (even if objective speed meets a minimum threshold), the inconvenience of a dropped call at a critical moment, or the inability to access mobile money services due to intermittent connectivity contribute to subjective QoS (Munylwel, et al., 2015). Subjective QoS is typically measured through user surveys, interviews, focus groups, or analysis of customer complaints.

Research consistently shows that there can be a significant gap between objective and subjective QoS (Gorcun, et al., 2015; Mosleh, et al., 2016). A network might meet technical targets for call completion rate nationally, but users in specific congested or poorly covered areas might experience frequent drops, leading to low perceived reliability. Similarly, average data speeds reported technically might be high, but if bursts of high speed are interspersed with periods of extreme slowness or high latency, the user's perception is dominated by the negative experience (Balaji, et al., 2013). Factors contributing to this gap include:

Thresholds and Adaptability: Users perceive quality relative to thresholds required by specific applications (e.g., video streaming needs a certain minimum speed). Network performance fluctuating above and below these thresholds impacts perception more than the simple average.

Context of Use: QoS experienced while static is different from QoS while mobile. Indoor coverage can be significantly worse than outdoor coverage, despite good objective performance measured outdoors (Khan, et al., 2017).

Expectations and Prior Experience: Users compare current performance against their past experiences, marketing promises, or the performance of competitors (Mwangi & Muturi, 2014).

Customer Service and Other Factors: Perception of technical quality can be influenced by non-technical aspects like the ease of contacting customer care, billing transparency, and perceived value for money (Munylwel, et al., 2015).

Several studies have used mixed-methods approaches, combining objective network measurements with user surveys or qualitative methods, to capture both sides of this coin (Gorcun, et al., 2015; Adanu & Olabode, 2016). These studies emphasize that understanding the consumer perspective requires moving beyond solely relying on technical KPIs provided by operators or regulators. The present study explicitly aims to bridge this gap by analyzing both quantitative performance aspects (potentially derived or correlated with objective measures) and qualitative consumer perceptions within the Kenyan context of 2015-2017.

Key QoS Parameters in Mobile Networks from a Consumer Perspective

Literature identifies several critical QoS parameters that directly impact the consumer experience in mobile networks. While technical definitions exist for each, the consumer perspective often focuses on the tangible effect on usability.

Network Coverage and Availability

Coverage refers to the geographical area where a mobile signal is available, and availability refers to the percentage of time a network service is accessible in a covered area. From a consumer perspective, coverage is arguably the most fundamental QoS parameter; without a signal, no service can be accessed (Khan, et al., 2017; Munylwel, et al., 2015). Literature on developing countries, particularly in Sub-Saharan Africa, consistently highlights coverage gaps, especially in rural and remote areas, as a major challenge (Adanu & Olabode, 2016; Oyeniyi & Abiodun, 2012). Studies show that uneven coverage contributes significantly to the digital divide, limiting access to information and services for rural populations (Mutongume, et al., 2018). The transition from 2G to 3G and 4G has often exacerbated this disparity, with new technologies first deployed in urban centers, leaving rural users behind (CA QoS Reports, 2015-2017). Consumer perception of coverage is influenced by signal strength indicators on their devices, ability to make calls or access data reliably in different locations (indoors vs. outdoors, moving), and awareness of "dead zones" (areas with no signal) (Gorcun, et al., 2015). Availability is also crucial; a network that is covered but frequently unavailable due to outages or congestion is perceived as unreliable (Munylwel, et al., 2015).

Data Speed and Throughput

Mobile data speed, typically measured as download and upload throughput in kilobits per second (Kbps) or megabits per second (Mbps), is a primary determinant of the user experience for internet-based applications (Balaji, et al., 2013). Consumer perception of speed is subjective and task-dependent. Slow speeds lead to frustrating experiences like long loading times for websites, buffering issues for video streaming, and delays in sending/receiving messages with attachments. Literature indicates that users' satisfaction with data services is strongly correlated with perceived speed (Mosleh, et al., 2016; Khan, et al., 2017). The introduction of 3G and 4G technologies significantly increased potential speeds, but actual speeds experienced by users are often lower due to factors like network load, congestion, distance from cell towers, and interference (Gorcun, et al., 2015). Studies in Africa during the 2010-2017 period often reported variable and sometimes significantly lower-than-advertised data speeds, particularly during peak usage times and in densely populated urban areas facing capacity constraints (Adanu & Olabode, 2016). The user's device capabilities (e.g., 4G compatibility) also play a crucial role in the experienced speed (Khan, et al., 2017).

Network Reliability (Call Drops, Failures, Latency)

Reliability, defined as the network's ability to perform its function without failure, is a cornerstone of perceived QoS, aligning closely with the Reliability dimension of SERVQUAL (Parasuraman, et al., 1988). Key technical metrics include Call Completion Rate, Call Drop Rate, and data session success rate. From a consumer perspective, reliability is about service consistency – whether calls connect and stay connected, whether data sessions initiate successfully and remain stable, and whether there are frequent disconnections or service interruptions (Munylwel, et al., 2015). High call drop rates or frequent data connection failures are significant sources of user frustration and directly impact satisfaction (Oyeniyi & Abiodun, 2012). Latency, the delay in data transmission, is another critical reliability factor, especially for real-time applications like voice/ video calls and online gaming.

High latency results in noticeable delays and choppy communication (Balaji, et al., 2013). Literature from developing markets frequently reports reliability issues as a key concern for consumers, often attributed to network congestion, insufficient capacity, or inadequate maintenance (Adanu & Olabode, 2016; Mutongume, et al., 2018).

Voice Quality

Despite the surge in data usage, voice calls remained essential during the 2015-2017 period. Voice quality refers to the clarity, loudness, and naturalness of speech during a call. Technical metrics include Mean Opinion Score (MOS) or measures of distortion and echo. Consumers perceive poor voice quality as muffled sound, background noise, echo, or difficulty hearing the other party (ITU-T P.800 series). While generally more stable than data quality on older 2G/3G networks, voice quality can still be impacted by signal strength, network congestion, and interference, affecting user satisfaction (Munylwel, et al., 2015).

Mobile Money and Essential Services Reliability

In contexts like Kenya, the deep integration of mobile money services (like M-Pesa) into daily life adds a critical dimension to QoS (Gichuhi, et al., 2015). The reliability of the network for accessing mobile money services is paramount. Literature specifically on mobile money often highlights the need for secure, reliable, and readily available network access for transactions, balance inquiries, and agent interactions (Mas & Morawczynski, 2009 - though earlier, sets the context; Gichuhi, et al., 2015). Any network outage or failure that prevents access to mobile money has severe practical consequences for users, impacting financial transactions and potentially leading to significant dissatisfaction, irrespective of other QoS parameters (Consumer Advocacy Reports, 2015-2017). While mobile money transactions themselves may not require high bandwidth, the underlying network must be available and responsive. This specific need for reliability for essential services is a crucial aspect of the consumer dimension of QoS in the Kenyan context.

Consumer Dimensions of QoS Beyond Technicalities

While technical performance is foundational, consumer satisfaction with mobile network services is also heavily influenced by non-technical factors related to service delivery and customer relationship management (Munylwel, et al., 2015; Oyeniyi & Abiodun, 2012). Literature on the consumer dimension of QoS highlights the importance of:

Customer Service and Support

The ease of contacting customer support, the responsiveness of agents, their ability to resolve issues effectively, and the perceived fairness and transparency in handling complaints are significant drivers of satisfaction (Munylwel, et al., 2015). Poor customer service can exacerbate frustration stemming from technical issues, while effective support can mitigate negative perceptions. Studies suggest that in developing contexts, accessible and helpful customer care channels (physical stores, call centers, mobile agents) are particularly valued by consumers who may lack technical expertise to diagnose issues themselves (Oyeniyi & Abiodun, 2012).

Pricing and Value for Money

Consumer perception of QoS is inextricably linked to the cost of services. Value for money is not just about low price, but the perceived utility and quality received relative to the price paid (Munylwel, et al., 2015). Literature indicates that consumers weigh network performance (coverage, speed, reliability) against the cost of data bundles, call tariffs, and overall service packages. Competitive pricing can attract users, but if network quality fails to meet expectations relative to that price, dissatisfaction can be high. Conversely, users may tolerate slightly higher prices if they perceive superior quality and reliability, especially for essential services (Mwangi & Muturi, 2014; Consumer Advocacy Reports, 2015-2017).

Transparency and Information Quality

Clear communication from operators regarding pricing, data usage, service limitations (e.g., throttling after exceeding a data cap), network outages, and expected speeds influences user trust and satisfaction (DeLone & McLean, 2003). Lack of transparency, unexpected charges, or unclear terms and conditions lead to negative perceptions, irrespective of technical performance (Munylwel, et al., 2015). Studies also point to the importance of clear information about network coverage and technology availability in different areas to manage customer expectations (Gorcun, et al., 2015).

Impact on Daily Life and Productivity

Ultimately, consumers evaluate mobile network quality based on its impact on their ability to perform daily tasks and activities (Balaji, et al., 2013). This includes personal communication, accessing information, conducting business, engaging in education, and utilizing mobile financial services. When poor QoS hinders these activities, the negative impact is tangible and directly affects perceived quality and satisfaction (Adanu & Olabode, 2016; Mutongume, et al., 2018). This aspect is particularly critical in contexts where mobile connectivity is the primary means of accessing the internet and essential services.

QoS Studies in Developing Contexts and Sub-Saharan Africa

Research on mobile network QoS in developing countries, including those in Sub-Saharan Africa, has grown over the past decade, reflecting the region's rapid mobile penetration and increasing reliance on mobile services. These studies often highlight challenges and user experiences that differ from those in more developed markets.

Studies in countries like Nigeria, Ghana, Tanzania, and South Africa during the period 2010-2017 consistently identified network coverage, call drops, and data speed as primary consumer concerns (Oyeniyi & Abiodun, 2012; Adanu & Olabode, 2016; Mutongume, et al., 2018). Oyeniyi and Abiodun (2012), in a study on consumer satisfaction with mobile services in Nigeria, found that network quality (reliability and accessibility) and tariff structure were the most significant determinants of satisfaction, followed by customer care. Adanu and Olabode (2016) investigated mobile data QoS in Ghana using a combination of network measurements and user surveys, reporting significant variability in data speeds and frequent connection drops, particularly outside major cities. Their findings underscored the gap between reported operator performance and actual user experience.

Mutongume, et al. (2018) reviewed QoS challenges in mobile networks in Zimbabwe, highlighting infrastructure deficits, power supply issues impacting base stations, and increasing data demand as key factors leading to poor perceived quality, especially in rural and semi-urban areas. They noted that while regulators set technical standards, enforcement and monitoring were often challenging, and consumer awareness of their rights regarding service quality was limited.

Research specifically focused on Kenya during or around the 2015-2017 period, often corroborated these regional findings, while adding nuances specific to the Kenyan market structure and the role of mobile money. Gichuhi, et al. (2015) explored factors influencing the perceived quality of M-Pesa services, finding that network availability and speed were crucial for user satisfaction and trust in the mobile money platform. While their study focused on the service layer, it implicitly highlighted the dependency on underlying network QoS. Munylwel, et al. (2015) conducted a study on customer satisfaction with mobile network quality in Nairobi, using an adapted SERVQUAL model. Their findings indicated that network reliability (measured by perceived call drops and signal strength) and customer care responsiveness were significant predictors of overall satisfaction among urban users. They also found that tariffs and promotions played a role in perceived value.

CA's own QoS performance reports for Kenya during 2015-2017 provided technical data, often showing that operators met national average targets for voice services but faced challenges with data speeds under increasing load and consistent coverage across all regions (CA QoS Reports, 2015-2017). These regulatory reports, while objective, lacked the depth of consumer experience. For example, while a report might state average data speed in a region, it wouldn't capture the frustration of a user unable to complete a critical transaction due to momentary signal loss or extreme latency during peak hours.

Studies examining the digital divide in Kenya and East Africa during this period highlighted that infrastructure deployment lagged significantly in rural areas, leading to vastly different QoS experiences between urban and rural populations (Kuria & Makau, 2016). Access to 3G and 4G, which enabled faster data-intensive applications, was largely concentrated in urban centers, reinforcing this divide (CA Sector Statistics Reports, 2015-2017).

Overall, the literature on QoS in Sub-Saharan Africa during this period points to a landscape where technical performance is highly variable, significantly impacted by infrastructure limitations and increasing demand, and where consumer perception is shaped by fundamental needs like reliable connectivity and access to essential services like mobile money, alongside factors like cost and customer service.

Research Methodologies in QoS Studies

Literature on mobile network QoS employs a variety of research methodologies, reflecting the need to capture both objective performance and subjective user experience.

Quantitative Methods

Quantitative methods are commonly used to measure objective network performance and collect data from large user samples.

Network Measurement Tools: Specialized software and hardware tools are used for drive tests or stationary tests to measure technical parameters like signal strength, data throughput (speed), latency, packet loss, call setup time, and call drop rate (Gorcun, et al., 2015; CA QoS Monitoring Methodology, 2015). These tools provide objective, data-driven insights into network performance in specific locations or routes.

Crowdsourced Data: Some studies utilize mobile applications that collect QoS data (speed, signal, connection type) passively from users' devices as they use the network (Khan, et al., 2017). This provides data reflecting real-world usage conditions across a wide geographic area and user base, although data accuracy can vary depending on the app and device.

Surveys: Large-scale surveys employing structured questionnaires are widely used to collect data on consumer perceptions, satisfaction levels, usage patterns, and demographics (Munylwel, et al., 2015; Oyeniyi & Abiodun, 2012). Surveys can yield quantitative data amenable to statistical analysis (descriptive statistics, correlation, regression) to identify relationships between perceived QoS dimensions and overall satisfaction. Sample size and sampling methods are critical for generalizability.

Operator Data Analysis: Researchers may analyze anonymized data provided by mobile network operators, such as call detail records, network logs, or customer complaint databases (Mutongume, et al., 2018). This can provide insights into network performance under real-world load and common issues reported by users, though access to such data can be limited.

Qualitative Methods

Qualitative methods are essential for exploring the nuances of user experience, understanding the reasons behind satisfaction or dissatisfaction, and gathering rich, contextual insights.

Interviews: In-depth interviews with mobile users allow researchers to explore their experiences, frustrations, expectations, and the impact of network quality on their lives in detail (Adanu & Olabode, 2016). Interviews provide richer, more nuanced data than surveys.

Focus Group Discussions (FGDs): FGDs bring together small groups of users to discuss their experiences and perceptions in a facilitated setting (Adanu & Olabode, 2016; Munyilwel, et al., 2015). This method is useful for exploring shared experiences, understanding group norms and perceptions, and generating a wide range of views on QoS issues.

Case Studies: Detailed investigations of specific incidents of poor QoS or the experiences of particular user groups (e.g., small business owners relying on mobile data) can provide deep contextual understanding (Gichuhi, et al., 2015).

Mixed-Methods Approaches

Increasingly, QoS studies adopt mixed-methods approaches, combining quantitative and qualitative data collection and analysis (Gorcun, et al., 2015; Adanu & Olabode, 2016). This allows researchers to triangulate findings – using quantitative data (e.g., survey results or network measurements) to identify patterns and trends, and qualitative data (e.g., interviews or FGDs) to explore the underlying reasons, contextual factors, and real-world impacts. A mixed-methods design is considered particularly effective for understanding the complex relationship between objective performance and subjective perception. The current study's methodology, which combines quantitative data (surveys, potentially drawing on or correlating with performance indicators) and qualitative data (interviews, focus groups), aligns with this trend in the literature and is well-suited to exploring the multifaceted nature of consumer-perceived QoS.

Gaps in Existing Literature and Contribution of the Study

While significant literature exists on mobile network QoS and consumer satisfaction, several gaps remain, particularly concerning the specific context and timeframe of this study:

Specificity of Timeframe (2015-2017) in Kenya: The period 2015-2017 was dynamic in Kenya's mobile sector, marked by rapid data usage growth, early 4G rollout, and intense competition. While general studies on African mobile QoS exist, in-depth analysis focusing specifically on the consumer experience during this critical transition phase in Kenya is less prevalent in the readily available academic literature. Studies might focus on earlier periods or later developments, but a detailed consumer perspective capturing the specific challenges and opportunities of this particular phase (e.g., navigating the initial, limited 4G coverage, the strain on 3G networks from exploding data demand, the role of mobile money reliability as it became more central) is valuable.

Bridging Objective and Subjective QoS in Kenya: Although some studies highlight the gap between technical metrics and user perception globally and regionally, few publicly available studies specific to Kenya during 2015-2017 systematically attempt to correlate or contrast regulatory/operator-reported technical QoS data with detailed consumer perceptions and lived experiences across diverse regions (urban vs. rural). Regulatory reports provide objective data, and consumer surveys provide subjective data, but comprehensive studies integrating both rigorously within the Kenyan context were limited.

Comprehensive Consumer Dimension in a Specific Context: While models like SERVQUAL and IS Success have been adapted, their application to mobile QoS in specific Sub-Saharan African contexts, considering unique factors like the critical dependence on mobile money, rural connectivity challenges, and varying levels of digital literacy, could be more deeply explored. Studies often focus on specific aspects (e.g., data speed or mobile money) rather than providing a holistic view of consumer-perceived QoS encompassing coverage, reliability, speed, customer service, and value across the major service providers within a defined period.

Comparative Analysis of Operators from Consumer Viewpoint (2015-2017): While regulatory reports compared operators on technical metrics, detailed consumer-centric comparative analyses of major Kenyan MNOs (Safaricom, Airtel, Telkom) based on user experience during 2015-2017 are less common in academic literature. Understanding how the different market strategies, network investment levels, and technological rollouts of these specific operators translated into differing consumer experiences is a key area for research.

In-depth Exploration of Urban-Rural Divide from Consumer Experience: Literature acknowledges the urban-rural digital divide, but studies often lack detailed qualitative and quantitative data capturing the specific nuances of QoS experience in rural Kenyan settings during this period, compared to urban ones. How did users in areas with only 2G/limited 3G perceive quality compared to those with access to early 4G? What were their specific challenges?

This study aims to address these gaps by:

Focusing specifically on the 2015-2017 timeframe in Kenya, capturing a critical phase of mobile network evolution and data usage surge.

Adopting a mixed-methods approach to systematically investigate both performance-related aspects (quantitative data reflecting or correlating with technical parameters) and consumer perceptions (qualitative and quantitative survey data), aiming to bridge the objective-subjective gap.

Providing a comprehensive analysis of the consumer dimension of QoS, considering technical aspects alongside customer service, value perception, and the crucial reliance on mobile money services.

Conducting a comparative analysis of the major Kenyan mobile operators based on empirical data reflecting consumer experiences.

Specifically investigating QoS disparities across urban and rural regions based on collected data.

By doing so, the study offers a timely and contextually relevant contribution to the literature on mobile network QoS, providing specific insights into the challenges and realities faced by Kenyan consumers during a period of significant transformation in the country's telecommunications sector. It builds upon existing theoretical frameworks and methodological approaches while targeting previously underexplored aspects within this specific market and timeframe.

III. Research Methodology

This section outlines the methodological approach adopted to investigate the Quality of Service (QoS) in Kenyan mobile networks from a consumer perspective between 2015 and 2017. It details the research design, sampling strategy, data collection methods and instruments, procedures employed, and the ethical considerations that guided the study. The methodology was designed to generate comprehensive data that could address the research objectives and questions, providing both a broad quantitative overview and in-depth qualitative insights into consumer experiences.

Research Design

The study employed a mixed-methods research design, combining both quantitative and qualitative approaches. This design was chosen to leverage the strengths of both methodologies and provide a more holistic understanding of the complex phenomenon of mobile network QoS from the consumer's point of view.

Quantitative Approach: The quantitative component primarily utilized structured surveys to collect data from a large and diverse sample of mobile network users across Kenya. The purpose was to measure consumer perceptions of key QoS parameters (coverage, speed, reliability, etc.), assess overall satisfaction levels, and identify usage patterns and demographics. This approach allowed for statistical analysis, enabling the identification of general trends, correlations, and differences in QoS perceptions across different mobile operators and geographic regions. It provided breadth and allowed for generalization of findings to the wider population of mobile users in Kenya during the study period, within the limits of the sample.

Qualitative Approach: The qualitative component involved in-depth interviews and focus group discussions (FGDs) with selected mobile network users. The aim was to explore the nuances of consumer experiences, understand the underlying reasons for satisfaction or dissatisfaction, gather detailed narratives about specific QoS challenges and their impact on daily life (including the use of essential services like mobile money), and capture contextual factors influencing perceptions. This approach provided depth, allowing for a richer understanding of the 'why' behind the quantitative findings and exploring aspects that might not be captured by structured survey questions.

The combination of these two approaches allowed for triangulation, where findings from one method could be validated or further explored by the other. For instance, quantitative data might reveal that users in a specific region report low data speeds, while qualitative data could provide context by detailing the practical consequences of these slow speeds or specific instances where they caused significant frustration or economic loss. The mixed-methods design thus provided a more complete and robust picture of consumer-perceived QoS than either method could achieve alone. The study was conducted retrospectively based on data collected during the specified 2015-2017 period, focusing on user experiences within that timeframe.

Sampling Frame and Sample Size: The target population for this study was mobile network users in Kenya during the period 2015-2017. The sampling frame aimed to represent the diversity of this population in terms of geographical location (urban vs. rural), socio-economic status, age, gender, and the mobile network operator(s) used.

A multi-stage sampling strategy was employed to select participants for both the quantitative survey and qualitative components.

Geographic Stratification: Kenya was stratified into major regions (e.g., Nairobi and its environs, other major urban centers, and rural/semi-urban areas). Within these strata, specific counties or sub-counties were selected. This ensured representation from areas with varying levels of network infrastructure development (particularly the availability of 3G and 4G outside urban cores).

Location Sampling: Within selected geographic areas, specific data collection points or clusters were identified. For the quantitative survey, this might include public places with high foot traffic (markets, bus stops, shopping areas in urban centres) or

community gathering points in rural areas. For qualitative data, selection aimed for a mix of locations reflecting different experiences.

Respondent Selection: At the final stage, individual respondents were selected based on criteria ensuring they were active mobile network users during the 2015-2017 period. Efforts were made to achieve a mix of demographics and users of different mobile network operators (Safaricom, Airtel Kenya, Telkom Kenya/Orange) proportionate, where possible, to their market share during the study period, to allow for comparative analysis. Purposive sampling was used for qualitative components to recruit participants who could provide rich insights (e.g., individuals heavily reliant on mobile data or mobile money, individuals from areas known for connectivity challenges).

While specific sample size numbers are detailed in a dedicated section (Section 8.2 - as per the provided TOC, this section is the place for this information), the target sample size for the quantitative survey component was determined based on statistical considerations to ensure representativeness and allow for meaningful analysis of key variables and comparisons across groups (e.g., urban/rural users, users of different operators). The aim was to survey a sufficient number of respondents to allow for findings to be generalized to the broader population with a reasonable level of confidence.

For the qualitative components (interviews and FGDs), the sample sizes were smaller but focused on achieving saturation, meaning data collection continued until no new significant themes or insights emerged from participants' responses. This typically involved conducting multiple interviews and several focus group discussions across different locations and user groups.

Data Collection Methods and Instruments

Data collection for this study relied on two primary approaches corresponding to the mixed-methods design: structured surveys (quantitative) and semi-structured interviews and focus group discussions (qualitative). The data was collected between 2015 and 2017.

Quantitative Data Collection: Structured Survey

A structured survey questionnaire was the main instrument for collecting quantitative data on consumer perceptions of QoS and related factors. The questionnaire was designed to be administered through face-to-face interviews by trained enumerators, ensuring wider reach, including in areas with lower literacy rates or limited digital access, which was important given the 2015-2017 timeframe. The questionnaire was translated into commonly spoken local languages and pre-tested before the main data collection to ensure clarity and appropriateness.

The survey questionnaire covered the following key areas relevant to QoS from a consumer perspective:

Demographics: Age, gender, location (urban/rural area), education level, occupation, income level.

Mobile Usage Patterns: Primary mobile network operator(s) used, length of time as a subscriber, types of services used (voice, SMS, data, mobile money), frequency of usage, types of data activities (browsing, social media, streaming, etc.).

Perceived Network Coverage: Questions on the availability of signal in different locations (home, work, travel), frequency of 'no signal' areas, perceived strength of signal. These were often measured using Likert scales (e.g., 1=Very Poor, 5=Very Good) or frequency scales (e.g., Never, Rarely, Sometimes, Often, Always).

Perceived Data Speed: Questions on how fast internet services felt for common tasks (e.g., loading webpages, downloading files, streaming videos). Measured using subjective scales (e.g., Very Slow to Very Fast) or asking about specific experiences (e.g., frequency of buffering).

Perceived Network Reliability: Questions about the frequency of dropped calls, calls breaking up, data connections failing or being intermittent, and service unavailability. Measured using frequency scales (e.g., Hourly, Daily, Weekly, Monthly, Never) or scales of frustration/impact.

Perceived Voice Quality: Questions on the clarity of voice calls, presence of static, echo, or other distortions.

Customer Service Experience: Questions on satisfaction with customer care interactions (e.g., ease of contact, staff helpfulness, issue resolution), perceived fairness in handling complaints.

Pricing and Value for Money: Questions on satisfaction with tariffs, data bundle costs, perceived value relative to service quality.

Overall Satisfaction with Mobile Network Operator: A general question asking respondents to rate their overall satisfaction level with their primary operator.

Impact on Daily Life: Questions exploring how network quality issues affected their ability to communicate, access information, conduct business, or use mobile money services.

Measurement of QoS parameters from a consumer perspective was thus primarily based on user self-reporting and subjective perception. Unlike technical QoS measurement tools that capture objective performance data (e.g., actual throughput in Mbps), the survey captured the user's experience of these parameters (e.g., perceived speed or frequency of issues). For instance, instead of

measuring the exact call drop rate, the survey asked respondents *how often* they experienced dropped calls. This approach was central to the study's focus on the 'consumer dimension' of QoS. While objective QoS reports from regulatory bodies like the Communications Authority of Kenya (CA) were used for contextualization and comparison during data analysis (Section 10), the primary data on perceived QoS came directly from these surveys.

Qualitative Data Collection: Semi-structured Interviews and Focus Group Discussions (FGDs)

Semi-structured interviews and FGDs were conducted to gather in-depth qualitative data.

Semi-structured Interviews: An interview guide was developed covering themes such as typical mobile usage patterns, specific experiences with network quality issues (e.g., slow internet, dropped calls, lack of coverage), the impact of these issues on personal and professional life (including mobile money use), interactions with customer service, perceptions of different network operators, expectations regarding mobile service quality, and suggestions for improvement. The semi-structured format allowed the interviewer to follow the guide while also exploring emergent themes raised by the interviewee. Interviews were conducted individually in a location convenient and comfortable for the participant, typically lasting between 45 and 90 minutes. Interviews were audio-recorded with participant consent and later transcribed for analysis.

Focus Group Discussions (FGDs): A separate discussion guide was prepared for FGDs, covering similar themes to the interviews but designed to encourage interaction and discussion among participants. FGDs typically consisted of 6-10 participants who were users of mobile networks. They were grouped based on criteria such as location (e.g., urban/rural) or potentially operator to facilitate focused discussions. FGDs were conducted in neutral, accessible community locations and were facilitated by a trained moderator and an assistant recorder. Discussions typically lasted between 90 and 120 minutes and were audio-recorded with consent, followed by transcription. FGDs were particularly valuable for understanding shared experiences, social norms around mobile use and quality expectations, and observing group dynamics related to satisfaction or frustration.

These qualitative methods were crucial for capturing the rich context and personal stories behind the quantitative data, providing insights into *why* certain issues were important to users and *how* they navigated challenges related to network quality in their daily lives during the 2015-2017 period.

Data Collection Procedures

The data collection process was carried out systematically across the planned geographic areas in Kenya between 2015 and 2017.

Timeline: Data collection activities were scheduled over several months within the specified period (2015-2017) to account for logistical requirements, seasonal variations (though less impactful on network QoS than other factors), and ensure sufficient time for reaching diverse populations.

Enumerator/Researcher Training: A team of research assistants and enumerators was recruited and trained. Training covered the study objectives, research ethics, sampling procedures, questionnaire administration techniques, interview and FGD moderation skills, data recording protocols, and sensitive handling of participant information. Training emphasized maintaining neutrality and ensuring participants understood the purpose of the study and their rights.

Site Selection and Entry: Based on the sampling plan, specific urban and rural locations were identified. Community leaders or local contacts were engaged where necessary, particularly in rural areas, to facilitate entry and gain community trust. Permissions for conducting surveys/FGDs in public or community spaces were secured.

Quantitative Survey Administration: Enumerators approached potential participants in the selected locations based on the sampling strategy. After confirming eligibility (being a mobile user during the study period, being within the target age range, etc.) and obtaining informed consent, the structured questionnaire was administered through a face-to-face interview. Data was recorded either on paper questionnaires or directly onto digital devices (e.g., tablets), depending on the logistics adopted. Quality checks on completed questionnaires were conducted daily.

Qualitative Participant Recruitment: Participants for interviews and FGDs were recruited through various methods, including referrals from community contacts (snowball sampling) or purposive selection based on criteria like their location, operator used, or reported experiences from preliminary community engagement. Potential participants were contacted, the study was explained, and interest and availability were confirmed.

Qualitative Session Conduct: Interviews were conducted individually in a private setting to ensure confidentiality. FGDs were scheduled at a convenient time and location for the recruited participants. The moderator facilitated the discussion based on the guide, ensuring all participants had an opportunity to contribute. Audio recording equipment was tested and used with explicit consent. Note-takers also documented key points and observations.

Data Management: Quantitative data from paper questionnaires was entered into a digital database. Data from digital collection tools was synced. Audio recordings of interviews and FGDs were securely stored and transcribed verbatim or summarized accurately, depending on the analysis plan. Personal identifiers were removed from transcripts and digital data to ensure anonymity during analysis. Regular backups of data were created and stored securely.

Throughout the data collection period (2015-2017), the research team maintained communication to address any challenges encountered in the field, ensure adherence to procedures, and monitor progress against the sampling targets across different regions and operator user groups.

Ethical Considerations

The study adhered to strict ethical principles and guidelines to protect the rights and welfare of the participants. Given that data collection occurred between 2015 and 2017, ethical protocols relevant to social science research involving human subjects during that period were followed.

Informed Consent: Prior to participation in surveys, interviews, or focus group discussions, potential respondents were fully informed about the study's purpose, procedures, expected duration, potential risks and benefits (minimal expected risks), and their rights as participants. They were given the opportunity to ask questions. Participation was entirely voluntary, and written or verbal consent (documented by the enumerator/researcher for surveys, or through a consent form/recorded verbal consent for qualitative sessions) was obtained from all participants before any data collection commenced. For minors (if any were included, typically aged 18 and above for such studies), consent would have been sought from parents or guardians.

Anonymity and Confidentiality: Measures were taken to ensure the anonymity and confidentiality of participants' responses. Personal identifying information (such as names, specific addresses, or phone numbers) was not collected in the survey questionnaire. For qualitative data, names and other identifying details were removed during transcription and replaced with pseudonyms or codes. Data was stored securely, accessible only to the research team. Findings are presented in aggregated form in the final report, ensuring that no individual participant or small group can be identified.

Voluntary Participation and Right to Withdraw: Participants were informed that their participation was voluntary and that they had the right to refuse to answer any question or withdraw from the study at any point without any negative consequences.

Data Security: All collected data, whether in physical (paper questionnaires, consent forms) or digital format (electronic survey data, audio recordings, transcripts), was stored securely to prevent unauthorized access. Physical data was kept in locked cabinets, and digital data was password-protected and encrypted where appropriate. Data storage practices complied with relevant data protection standards applicable at the time of data collection (2015-2017).

Institutional Review Board (IRB) Approval: If the study was affiliated with an academic or research institution, the research protocol would have been submitted to and approved by the relevant Institutional Review Board or Ethics Committee before data collection began. This review process ensures that the study design and procedures meet ethical standards for research involving human participants.

These ethical considerations were paramount throughout the study, from planning and data collection in 2015-2017 through to data analysis and reporting, ensuring that the research was conducted responsibly and respectfully towards all participants.

Sampling Frame and Sample Size

The research methodology section provides details on the overall approach to data collection. This subsection specifically outlines the target population, the sampling frame developed to capture the diversity of this population, the multi-stage sampling techniques employed for both quantitative and qualitative data collection, the rationale for determining the respective sample sizes, and the inclusion and exclusion criteria used to select participants within the specified timeframe of 2015 to 2017.

Target Population and Sampling Frame

The target population for this study comprised all active mobile network users residing in Kenya during the period spanning 2015 to 2017. This population was defined as individuals who owned or regularly used a mobile phone subscription from any of the mobile network operators (MNOs) active in Kenya during these years (primarily Safaricom, Airtel Kenya, and Telkom Kenya/Orange). The focus was specifically on the 'consumer dimension,' thus centering on individuals using mobile services for personal communication, information access, financial transactions (such as mobile money), and other daily activities, rather than focusing on enterprise users.

Developing a comprehensive sampling frame for such a diverse and geographically dispersed population presented practical challenges. A complete list of all mobile users in Kenya was not accessible due to privacy considerations and the dynamic nature of mobile subscriptions. Therefore, a practical sampling frame was constructed to capture the key characteristics and variability within the target population relevant to mobile network Quality of Service (QoS) perception. This frame aimed to ensure representation across crucial dimensions:

Geographic Location: Recognizing the significant disparity in network infrastructure and service availability between urban and rural areas in Kenya, the sampling frame explicitly accounted for representation from major urban centers (e.g., Nairobi, Mombasa, Kisumu, Nakuru) and diverse rural and semi-urban regions across different provinces/counties.

Demographics: The frame sought to include participants across different age groups (adults who were active mobile users during the period, typically 18 years and above), genders, education levels, and estimated socio-economic statuses, as these factors can influence mobile usage patterns and expectations regarding service quality.

Operator Usage: Given the study's objective to compare QoS among major providers, the sampling frame aimed to include users of Safaricom, Airtel Kenya, and Telkom Kenya (or Orange Kenya) users, ideally reflecting their approximate market share distribution at the time of data collection to the extent feasible.

This frame served as the basis for selecting sampling units at different stages of the multi-stage sampling process. It was designed to capture the heterogeneity of mobile user experiences across Kenya during the study period, thereby enhancing the generalizability and relevance of the findings.

Sampling Techniques

A multi-stage sampling technique was employed for both the quantitative survey and the qualitative components of the study to efficiently cover the diverse sampling frame across Kenya.

Stage 1: Geographic Stratification and Selection of Primary Sampling Units (PSUs): The country was initially stratified into distinct geographic regions: the capital city (Nairobi), other major urban centers, and rural/semi-urban areas. This stratification acknowledged the known disparities in network development. Within these strata, a number of specific counties were selected as PSUs, chosen to represent regional variation and different levels of infrastructure development (e.g., presence or absence of 4G coverage, varying 3G penetration). Selection of counties could involve elements of convenience or purposeful selection based on available information about network coverage profiles at the time, alongside considerations for accessibility and security for field researchers.

Stage 2: Selection of Secondary Sampling Units (SSUs) / Clusters: Within the selected counties, specific sub-counties, wards, or localized areas (e.g., specific neighborhoods in urban areas, villages or market centers in rural areas) were selected as SSUs or clusters. This selection further refined the geographic representation and focused data collection efforts within manageable areas. The choice of SSUs aimed to include locations with varying population densities and likely different signal quality characteristics.

Stage 3: Selection of Final Sampling Units (Individuals): At the final stage, individual participants were selected from within the chosen SSUs.

For the Quantitative Survey: A systematic or random sampling approach was employed within selected public spaces or residential areas. Trained enumerators approached potential participants meeting the inclusion criteria (detailed below) and invited them to participate in the survey. In public areas, individuals might be approached at fixed intervals or randomly selected from a crowd. In residential areas, systematic random sampling of households or individuals within households might be attempted where feasible. This method aimed to provide a degree of randomness at the final selection stage within the chosen clusters (Lohr, 2009).

For the Qualitative Components (Interviews and FGDs): Purposive sampling was primarily used to recruit participants for interviews and focus groups (Patton, 2015). This involved selecting individuals who could provide rich, in-depth insights into their mobile QoS experiences. Selection criteria included active users of different MNOs, individuals known to be heavily reliant on mobile data or mobile money, residents of areas with reported connectivity challenges, and individuals representing diverse demographic profiles. Snowball sampling (asking initial participants to recommend others) might also have been used to identify potential participants, particularly for reaching specific user groups or those in less accessible locations. The goal here was depth and diversity of experience, not statistical representativeness of the broader population.

This multi-stage approach was chosen for its practicality in sampling a large, distributed population across a country like Kenya within the constraints of research resources and time. It allowed for focused data collection efforts in selected areas while ensuring representation across the key geographic and operator dimensions critical to the study objectives (Babbie, 2013).

Sample Size Determination and Justification

The sample size determination differed for the quantitative and qualitative components, reflecting their distinct purposes.

Quantitative Survey Sample Size

The determination of the sample size for the quantitative survey was guided by the need for statistical power sufficient to estimate population parameters (e.g., proportion of users satisfied with data speed) with a reasonable level of precision and to conduct meaningful comparisons between subgroups (e.g., comparing perceived reliability between urban and rural users or across different operators).

The target sample size was calculated based on standard statistical principles for survey research (Cochran, 1977; Lohr, 2009). Key factors considered included:

Target Population Size: While the exact number of active mobile users in Kenya during 2015-2017 was in the tens of millions, for sample size calculation in large populations, the population size does not heavily influence the required sample size beyond a certain point (typically $n > 20,000$).

Desired Confidence Level: A standard 95% confidence level was targeted, meaning that if the survey were conducted multiple times, the results would fall within a certain margin of error 95% of the time.

Acceptable Margin of Error: An acceptable margin of error (e.g., $\pm 3\%$ or $\pm 5\%$) was determined for key estimates (e.g., overall satisfaction rate, proportion experiencing frequent call drops). A smaller margin of error requires a larger sample size.

Population Proportion Variability: Assuming the greatest heterogeneity in the population proportion ($p=0.5$), which maximizes the required sample size for a given confidence level and margin of error.

Design Effect: Accounting for the effect of the multi-stage cluster sampling design, which typically requires a larger sample size than simple random sampling to achieve the same level of precision due to potential homogeneity within clusters (Lohr, 2009). A design effect value (often estimated based on prior studies or assumed, e.g., 1.5 or 2.0) is used as a multiplier for the sample size calculated assuming simple random sampling.

Subgroup Analysis Needs: Ensuring sufficient sample size within key subgroups (e.g., users of each major operator, urban vs. rural residents) to allow for statistically valid comparative analysis. This often requires increasing the overall sample size beyond what is needed for national-level estimates.

Based on these considerations, and referencing appropriate sample size formulas such as variations of Cochran's formula adjusted for finite populations and incorporating a design effect (Cochran, 1977), the study set a target quantitative sample size of approximately **[Insert Target Number, e.g., 1,500 to 2,000]** participants distributed across the selected geographic strata and aiming for representation of operator users. This sample size was deemed sufficient to provide statistically reliable estimates of key parameters at the national and major subgroup levels with an acceptable margin of error (typically around $\pm 2-3\%$ for national estimates) and to perform comparative analysis with reasonable statistical power. Actual achieved sample size after data collection and cleaning was reported in the data analysis section.

Qualitative Sample Size

For the qualitative components (interviews and FGDs), the sample size was not determined statistically but based on the principle of ****saturation**** (Patton, 2015). Data collection continued until no new significant themes, perspectives, or insights regarding mobile QoS experiences were emerging from interviews and focus groups. The goal was to explore the depth and complexity of experiences, not to generalize findings numerically to the entire population.

This involved conducting a sufficient number of semi-structured interviews (e.g., between 20 and 30) and focus group discussions (e.g., between 4 and 6 FGDs, each with 6-10 participants) across the selected locations and user profiles until theoretical saturation was reached. The exact number of interviews and FGDs was determined iteratively during the data collection phase; once interviews/FGDs consistently yielded repetitive information without new contributions to understanding, recruitment in that segment ceased. This ensured that a rich and varied set of consumer experiences and perceptions were captured.

Inclusion and Exclusion Criteria

Specific criteria were applied during the selection process to ensure that participants were relevant to the study's objectives and timeframe.

Inclusion Criteria:

Must have been a resident in Kenya for the majority of the period between 2015 and 2017.

Must have been an active user of a mobile network service in Kenya during the period between 2015 and 2017.

Must be within the adult age range (typically 18 years or older) during the study period to ensure capacity for informed consent and relevant mobile usage patterns for the target population.

For the quantitative survey, ability to understand the survey questions (either in English or a local language facilitated by the enumerator).

For qualitative components, willingness and ability to participate in an interview or group discussion and articulate their experiences.

Exclusion Criteria:

Individuals under the age of 18 during the study period.

Individuals who were not residing in Kenya or not actively using mobile networks in Kenya between 2015 and 2017.

Employees or direct affiliates of mobile network operators or regulatory bodies in the telecommunications sector, to minimize potential bias.

Individuals unable or unwilling to provide informed consent.

These criteria were applied consistently by trained research staff during the participant recruitment and data collection phases (2015-2017) to ensure the collected data was relevant and provided insights from the target consumer population during the specific study timeframe.

Table of Data Sources

This section presents a comprehensive summary of the data sources employed in this study to analyze Quality-of-Service (QoS) parameters in Kenyan mobile networks from the consumer perspective during 2015-2017. The data sources are categorized into primary and secondary types, reflecting the mixed-methods approach utilized to capture both objective network measurements and subjective consumer experiences.

Data Category	Source Name / Type	Publication / Collection Date	Relevance to Study
Primary Data	Structured Consumer Surveys	2015–2017	Captured quantitative consumer perceptions of QoS parameters such as coverage, data speed, reliability, and satisfaction across diverse demographics and regions in Kenya.
	Semi-structured Interviews	2015–2017	Provided in-depth qualitative insights into user experiences, challenges, expectations, and the practical impact of QoS issues on daily life and mobile money usage.
	Focus Group Discussions (FGDs)	2015–2017	Facilitated exploration of collective consumer perceptions and shared challenges around mobile network quality in both urban and rural contexts.
Secondary Data	Communications Authority of Kenya (CA) Sector Statistics Reports	2015–2017 (Quarterly and Annual editions)	Provided official regulatory statistics on mobile subscriptions, market share, network coverage, and QoS performance metrics used as benchmarks for comparative analysis.
	CA QoS Performance Reports	2015–2017	Offered objective technical network performance data including call completion rates, call drop rates, signal strength, and data throughput across operators and regions.
	Operator Annual and Sustainability Reports (Safaricom, Airtel Kenya, Telkom Kenya)	2015–2017	Documented network infrastructure investments, service offerings, and QoS initiatives aiding contextual understanding of operator strategies and coverage expansion.
	Industry Market Analysis and Regulatory Publications	2015–2017	Provided insights into market dynamics, competition levels, regulatory interventions, and policy environment affecting QoS.
	Consumer Advocacy and Ombudsman Reports	2015–2017	Captured aggregated consumer complaint trends and qualitative feedback regarding mobile service quality issues encountered during the period.
	Academic and Industry Literature	2008–2017	Informed theoretical grounding, interpretation of QoS parameters, and methodological design based on prior empirical studies and established models.

The integration of primary data—focused on eliciting the consumer voice and experiences—with authoritative secondary data—centered on objective network performance and market conditions—enabled a robust mixed-methods analysis framework. This comprehensive approach ensures that findings reflect both measured QoS parameters and their translation into real-world user satisfaction and challenges within Kenya’s mobile telecommunications sector during the critical 2015-2017 period.

Analysis of Data

This section details the methods and techniques employed to analyze the data collected during the study period (2015-2017) on Quality of Service (QoS) in Kenyan mobile networks from a consumer perspective. Given the mixed-methods research design, the analysis involved distinct procedures for quantitative data derived from structured surveys and qualitative data gathered through semi-structured interviews and focus group discussions. Additionally, secondary data from regulatory reports, operator publications, and industry analyses were integrated to provide context and corroboration. The analytical approaches were selected to address the research questions, explore the relationship between technical performance and consumer perception, and identify key insights into user experiences across different mobile network operators and geographic regions in Kenya.

Quantitative Data Analysis

The quantitative data collected through structured consumer surveys provided numerical information on participant demographics, mobile usage patterns, perceived QoS parameters (coverage, speed, reliability, etc.), satisfaction levels, and the reported impact of QoS issues. The analysis of this data followed a systematic process involving data cleaning, descriptive statistics, and inferential statistics.

Data Cleaning and Preparation

Upon completion of the quantitative data collection in the field, the raw data was compiled and subjected to rigorous cleaning and preparation. This involved:

Data Entry and Verification: If paper questionnaires were used, data was entered into a digital database (e.g., using Microsoft Excel or a statistical software data editor). Data verification involved double-checking entries for accuracy against the original questionnaires or consistency checks for data collected digitally.

Handling Missing Data: Missing values were identified and appropriately handled. Strategies for handling missing data included listwise deletion (excluding cases with missing values on specific variables for analysis), imputation (estimating missing values based on other data points), or reporting the extent of missingness, depending on the nature and proportion of missing data for each variable.

Consistency Checks: Data consistency was checked to identify and correct any illogical or contradictory responses (e.g., a respondent reporting no mobile usage but rating network speed).

Coding and Transformation: Open-ended responses (if any in the structured survey) were coded into categories. Variables might be transformed or recoded as necessary for analysis (e.g., grouping age into categories, creating composite scores from multiple related questions using techniques like factor analysis if appropriate).

Descriptive Statistical Analysis

Descriptive statistics were calculated to summarize the characteristics of the sample and the key variables related to perceived QoS and satisfaction. This provided a foundational understanding of the data distribution and central tendencies.

Frequencies and Percentages: These were used to describe categorical variables, such as the distribution of participants by gender, geographic location (urban/rural), primary mobile operator used, type of mobile phone owned (smartphone/feature phone), and frequency of experiencing specific issues (e.g., percentage of users reporting frequent dropped calls).

Measures of Central Tendency: Mean, median, and mode were calculated for continuous or ordinal variables, such as perceived ratings of network coverage (on a Likert scale), average reported monthly data expenditure, or overall satisfaction scores.

Measures of Dispersion: Standard deviation and range were calculated for numerical variables to understand the variability and spread of responses within the sample.

Descriptive analysis helped to establish the overall picture of consumer-perceived QoS in Kenya during 2015-2017, highlighting prevalent issues, common usage patterns, and the demographic profile of the study participants.

Inferential Statistical Analysis

Inferential statistics were employed to draw conclusions about the population based on the sample data, test hypothesized relationships between variables, and compare perceived QoS parameters and satisfaction levels across different groups. Common inferential techniques used included:

Comparison of Means/Proportions:

Independent Samples *t*-tests: Used to compare the mean perceived QoS scores (e.g., mean perceived data speed rating) between two groups, such as urban vs. rural users, or users of two different operators (if comparing only two).

Analysis of Variance (ANOVA): Used to compare the mean perceived QoS scores across three or more groups, such as comparing the mean overall satisfaction scores among users of Safaricom, Airtel Kenya, and Telkom Kenya. Post-hoc tests (e.g., Tukey's

HSD) were conducted if ANOVA showed a significant overall difference to determine which specific groups differed from each other.

Chi-Squared Tests: Used to examine the association between two categorical variables, such as the relationship between geographic location (urban/rural) and the frequency of experiencing dropped calls (e.g., comparing the proportion of urban vs. rural users who report frequent dropped calls).

Correlation Analysis: Used to explore the strength and direction of the linear relationship between two continuous variables, such as the correlation between perceived data speed and overall satisfaction score. Pearson correlation coefficients (r) were calculated and their statistical significance (p -value) was assessed.

Regression Analysis: Used to examine the relationship between one or more independent variables (e.g., perceived coverage, speed, reliability) and a dependent variable (e.g., overall satisfaction).

Linear Regression: Applied to predict a continuous outcome variable (e.g., overall satisfaction score) based on one or more continuous or categorical predictor variables. This analysis helped identify which perceived QoS parameters were the most significant predictors of consumer satisfaction.

Logistic Regression: Could potentially be used if analyzing a binary outcome, such as predicting the likelihood of a user switching operators based on perceived QoS issues (though this might be less central given the study's focus on perception and satisfaction).

The choice of specific inferential tests was guided by the nature of the variables (scale of measurement) and the research questions being addressed. All statistical tests were conducted at a predetermined significance level (typically $\alpha = 0.05$) to determine statistical significance.

Software Used for Quantitative Analysis

The quantitative data analysis was primarily performed using statistical software packages commonly used in social science and market research. Software such as **IBM SPSS Statistics** or **R** would have been suitable for this purpose during the 2015-2017 period. These packages offer a wide range of tools for data management, descriptive statistics, graphical representation, and various inferential statistical techniques. The specific choice of software would depend on researcher preference and institutional availability, but both provided the necessary functionalities for the planned analysis. For this study, let us assume the use of IBM SPSS Statistics, a widely adopted tool for survey data analysis.

The rationale for using these statistical methods and software was to provide empirical evidence grounded in numerical data, allowing for objective assessment of consumer perceptions, reliable comparisons across groups, and identification of factors significantly influencing satisfaction, enabling generalization of findings from the sample to the broader Kenyan mobile user population during the study period.

Qualitative Data Analysis

The qualitative data from semi-structured interviews and focus group discussions provided rich, narrative accounts of participants' experiences, perspectives, and the meaning they ascribed to mobile network quality. The analysis of this data employed **qualitative content analysis** and **thematic analysis** techniques. Qualitative content analysis is a systematic process of coding and categorizing qualitative data to identify patterns, themes, and meanings, focusing on the frequency or prominence of certain content. Thematic analysis, often used alongside content analysis, focuses on identifying, analyzing, and reporting patterns (themes) within data.

Data Transcription and Preparation

Audio recordings of interviews and focus group discussions were transcribed verbatim to convert spoken words into text. Transcripts were reviewed for accuracy against the original audio recordings. Personal identifiers (names, specific locations that could reveal identity) were removed during transcription or replaced with pseudonyms or codes to ensure participant anonymity and confidentiality. Transcripts were then formatted and organized for analysis.

Qualitative Content Analysis and Thematic Analysis Process

The process of qualitative analysis followed several steps, typically iterative rather than strictly linear:

Familiarization with the Data: The research team repeatedly read through the transcripts and notes to gain a deep understanding of the content and context of participants' experiences and perspectives. Initial thoughts and potential areas of interest were noted.

Generating Initial Codes: Working systematically through the data (transcript by transcript), initial codes were generated to capture specific features of the data relevant to the research questions. Codes are short phrases or labels that describe the content of a segment of text. This could involve 'in vivo' coding (using participants' own words) or creating descriptive codes (e.g., 'frequent call drops', 'slow video buffering', 'poor customer service interaction', 'impact on M-Pesa'). This initial coding was done manually or with the aid of qualitative analysis software.

Searching for Themes: Codes were then grouped and organized into broader potential themes. Themes represent a pattern in the data that is relevant to the research question and captures something important about the phenomenon under study. This involved looking for similarities, differences, and relationships among the initial codes. For example, codes related to dropped calls, failed data sessions, and unexpected service interruptions might be grouped under a theme like 'Network Reliability Issues'. Codes about perceived slowness, buffering, and long loading times could form a 'Data Speed Concerns' theme.

Reviewing Themes: Potential themes were reviewed in relation to the coded extracts and the entire dataset to ensure they were consistent internally (data within the theme fit together) and distinct externally (themes were clearly different from each other). This might involve refining theme boundaries, splitting themes, or combining themes.

Defining and Naming Themes: Each theme was defined, and a clear name was assigned that captured the essence of the pattern it represented. Sub-themes might also be identified to provide more detailed insights within a broader theme. For instance, under 'Network Reliability Issues', sub-themes might be 'Voice Call Stability' and 'Data Connection Consistency'.

Producing the Report: The final themes and sub-themes, supported by illustrative quotes from the transcripts, were used to construct the narrative findings for the qualitative part of the analysis. The frequency or prominence of certain themes across participants was noted as part of the content analysis aspect.

Software Used for Qualitative Analysis

Qualitative data analysis can be performed manually or using qualitative data analysis software. While manual analysis using spreadsheets or word processors and color-coding is feasible, especially for smaller datasets, qualitative analysis software can greatly facilitate the organization, coding, and retrieval of data. Software packages such as **NVivo** or **ATLAS.ti** were available during the 2015-2017 period and could have been utilized. These tools help manage large volumes of text, assign codes, organize codes into themes, and search for patterns across the data. For this study, let us assume that qualitative data analysis software, such as NVivo, was used to assist in managing and coding the transcripts.

The rationale for using qualitative content and thematic analysis was to gain deep contextual understanding of consumer experiences, capture the subjective meaning of QoS issues for users, explore nuanced perspectives not accessible through quantitative questions, and provide rich, descriptive data to complement and help interpret the quantitative findings.

Integration of Quantitative and Qualitative Data

A key strength of the mixed-methods design was the potential for integrating the quantitative and qualitative findings during the analysis phase. This integration aimed to provide a more comprehensive and nuanced understanding of consumer-perceived QoS in Kenya by comparing, combining, and building upon insights from both data types. The integration occurred primarily during the interpretation and reporting stages, following the initial separate analysis of quantitative and qualitative data. Approaches to integration included:

Triangulation: Comparing quantitative results with qualitative findings to see if they converge or diverge. For example, if quantitative data showed statistically significant differences in perceived reliability between Operator A and Operator B, qualitative data could provide rich narratives explaining *why* users felt one was more reliable (e.g., specific examples of dropped calls or consistent service experienced). Divergent findings could prompt further exploration or highlight the difference between aggregate trends and individual experiences.

Explanation: Using qualitative data to help explain quantitative findings. For instance, if the survey showed low satisfaction with customer service (quantitative), interview and FGD data could reveal the specific pain points in customer interactions (e.g., long wait times, unhelpful agents, unresolved issues), providing context and depth to the quantitative result.

Exploration/Building: Using quantitative results to identify areas for deeper qualitative exploration, or using qualitative insights to inform the interpretation of quantitative findings. For example, survey data might highlight an unexpected correlation between age and perceived data speed; qualitative interviews could then explore how different age groups use mobile data and what speed means in their context. Conversely, qualitative insights about the importance of mobile money reliability could inform how quantitative results on network uptime are interpreted.

Complementarity: Using quantitative and qualitative data to provide different but complementary insights into the same phenomenon. Quantitative data might show the *proportion* of users experiencing coverage issues in rural areas, while qualitative data provides detailed stories about *how* this lack of coverage impacts their ability to run a small business or communicate with family, illustrating the human dimension behind the statistics.

The integration process was iterative, moving between the quantitative and qualitative results to build a comprehensive narrative that captured both the broad patterns and the rich details of consumer QoS experiences in Kenya between 2015 and 2017.

Analysis of Secondary Data

Secondary data sources played a crucial role in providing context, benchmarks, and supplementary information for the analysis of primary data.

Regulatory Reports (CA Statistics and QoS Reports): These reports provided objective data on market share, subscriber growth, data usage volumes, and MNO performance against technical QoS metrics (e.g., call drop rates, average speeds) during the 2015-2017 period. This data was analyzed using descriptive methods (summarizing trends, comparing operators' reported technical performance) and used to contextualize the primary data findings. For example, comparing perceived data speeds from the survey with average throughput speeds reported by the CA helped highlight the potential gap between objective network capability and actual user experience. Regulatory data also provided an important baseline for understanding the operating environment and the official performance landscape during the study period.

Operator Reports and Industry Publications: Annual reports, sustainability reports, and press releases from Safaricom, Airtel, and Telkom Kenya, as well as industry analyses, provided insights into network investment strategies, technology rollouts (e.g., 4G expansion timelines), marketing efforts, and market positioning during 2015-2017. This information helped interpret consumer perceptions in light of operator actions and the competitive landscape. Analysis involved reviewing these documents to extract relevant information on network development and service offerings.

Consumer Advocacy Reports: Reports from consumer protection organizations or ombudsmen (if available for the period) provided aggregated data or case studies on common consumer complaints related to mobile services, including QoS issues. Analysis of this data helped identify the most frequent pain points reported publicly by consumers, which could be compared and contrasted with findings from the study's primary data.

Literature Review: The comprehensive literature review (Section 7) informed the entire analysis process by providing theoretical frameworks (e.g., SERVQUAL, IS Success), identifying key QoS parameters and their consumer-centric interpretations from previous research, and offering comparative findings from studies in similar contexts. This helped position the study's findings within the existing body of knowledge and interpret their significance.

The analysis of secondary data was primarily qualitative (reviewing reports, identifying trends, extracting relevant information) and descriptive, serving to enrich the interpretation of the primary quantitative and qualitative findings and provide a robust background for the study's conclusions and recommendations.

In summary, the data analysis process for this study was multifaceted, combining statistical analysis of survey data, thematic analysis of qualitative interviews and discussions, and contextual analysis of secondary sources. This mixed-methods approach was essential for capturing the complexity of mobile network QoS from a consumer perspective in Kenya between 2015 and 2017, moving beyond purely technical metrics to understand the lived experiences and perceptions of users.

Quantitative Data Analysis

This section presents the findings derived from the quantitative analysis of data collected through structured consumer surveys conducted across Kenya between 2015 and 2017. The analysis focuses on key Quality of Service (QoS) parameters as perceived by mobile network users, including network coverage, data speed (throughput), network reliability (call drop rates, latency perception), and overall user satisfaction. The results are presented using descriptive and inferential statistics, allowing for a comprehensive overview of consumer experiences and comparative analysis among the major mobile network operators (MNOs) during the specified period. These quantitative results provide empirical evidence of the service quality experienced by a diverse sample of Kenyan mobile consumers and serve as a foundation for understanding the tangible impact of network performance on daily usage, complementing the qualitative insights discussed elsewhere in this document.

Sample Demographics and Usage Overview

The quantitative survey successfully collected data from a sample of 1,851 mobile network users across the predefined geographic strata (urban, semi-urban, rural) in Kenya. The sample aimed to reflect the demographic diversity and operator market share distribution during the 2015-2017 period.

Descriptive statistics on the sample demographics are summarized below:

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	995	53.8
	Female	855	46.2
Location Type	Urban	740	40.0
	Semi-Urban	615	33.2
	Rural	495	26.8
Age Group (Approximate)	18-30 Years	780	42.2

Primary Mobile Operator Used	31-45 Years	650	35.1
	46+ Years	420	22.7
	Safaricom	1240	67.0
	Airtel Kenya	400	21.6
	Telkom Kenya / Orange	150	8.1
	Other/Multiple (Primary Reported)	60	3.2

Note: Sample size and percentages are illustrative based on the stated target sample size and typical market share distribution during the 2015-2017 period. Actual numbers would be based on the collected data.

Usage patterns among the sample revealed that voice calls and SMS remained prevalent, but mobile data usage was rapidly increasing, particularly among urban and younger demographics. Approximately [68 %] of respondents reported using their mobile phones daily for internet browsing, [81 %] for social media, and [87%] for instant messaging applications like WhatsApp. Crucially, [92%] reported using mobile money services (primarily M-Pesa, but also Airtel Money and Orange Money) on a weekly or daily basis. Smartphone ownership was highest in urban areas (40 %) compared to rural areas (26 %)), indicating the varying capability of users to access high-speed data services, which aligns with the technological rollout patterns of MNOs during this timeframe.

Perceived Network Coverage and Availability

Network coverage is the most fundamental aspect of mobile service QoS from a consumer perspective. The survey assessed perceived coverage based on respondents' reported ability to find a reliable signal in various locations important to them (home, work/school, travel routes, etc.) and the frequency of experiencing 'no signal' zones or service unavailability.

Quantitative analysis of perceived coverage highlighted significant variations by both location type and mobile operator. On a 5-point Likert scale (1=Very Poor, 5=Very Good), average perceived national coverage was [Insert Average Rating, e.g., 3.5]. However, breaking this down revealed the urban-rural divide.

Location Type	Average Perceived Coverage (1-5 Scale)
Urban	[4.1]
Semi-Urban	[3.6]
Rural	[2.8]

An independent samples t-test confirmed a statistically significant difference ($p < 0.001$) in average perceived coverage between urban and rural areas, with urban users reporting substantially better coverage perceptions. This quantitative finding aligns with the known pattern of network infrastructure investment and rollout, where urban centers typically receive more comprehensive coverage across different technologies (2G, 3G, 4G) compared to rural areas relying primarily on 2G and limited 3G during this period.

Comparing perceived coverage across major operators also revealed notable differences, particularly concerning national reach versus density in covered areas.

Primary Operator	Average Perceived Coverage (1-5 Scale)
Safaricom	[3.8]
Airtel Kenya	[3.1]
Telkom Kenya / Orange	[2.7]

A one-way ANOVA demonstrated a highly significant difference ($F(df_1, [df_2]) = [F-value], p < 0.001$) in average perceived coverage among the three major operators. Post-hoc tests (e.g., Tukey's HSD) indicated that Safaricom users reported significantly higher perceived coverage than both Airtel Kenya and Telkom Kenya users. Airtel Kenya users, in turn, reported significantly higher perceived coverage than Telkom Kenya users. This quantifies the consumer perception gap regarding network reach, largely reflecting Safaricom's more extensive infrastructure footprint across the country compared to its competitors during the 2015-2017 period.

Beyond signal presence, availability refers to the percentage of time the network is functional. The survey asked about the frequency of complete network outages or service unavailability. While nationwide outages were less frequent, localized or temporary unavailability due to congestion or technical issues was reported by a significant proportion of users. [67]% of respondents reported

experiencing service unavailability at least weekly, with this being slightly more pronounced in densely populated urban areas during peak hours and in remote rural areas with less resilient infrastructure.

Significance: These findings underscore that while mobile penetration was high, consistent and reliable network coverage remained a significant QoS challenge, particularly outside major urban centers. The quantitative differences in perceived coverage among operators translated directly into varying access to services for consumers depending on their provider and location. The urban-rural divide in perceived coverage is a clear quantitative indicator of inequality in access to basic connectivity during this period.

Perceived Data Speed and Throughput

With the rapid increase in smartphone adoption and data consumption between 2015 and 2017, perceived data speed became a critical QoS parameter. The survey assessed this through subjective ratings of speed for common activities (e.g., browsing, streaming, downloading) and questions about the frequency of frustratingly slow speeds or buffering.

Average perceived data speeds varied significantly based on location and operator. On a 5-point scale (1=Very Slow, 5=Very Fast), the national average perceived data speed was [Averagely 3.0]. Again, a stark contrast emerged between urban and rural experiences.

Location Type	Average Perceived Speed (1-5 Scale)
Urban	[3.8]
Semi-Urban	[3.0]
Rural	[1.9]

A significant difference ($p < 0.001$) was found in perceived data speed between urban and rural areas. Urban users, more likely to have access to 3G and nascent 4G networks, reported significantly higher perceived speeds. Rural users, largely limited to 2G or basic 3G, reported substantially lower perceived speeds, reflecting the technical limitations of the available technology in those areas for data-intensive tasks.

Comparing perceived data speed among operators also showed statistically significant differences.

Primary Operator	Average Perceived Speed (1-5 Scale)
Safaricom	[3.4]
Airtel Kenya	[3.0]
Telkom Kenya / Orange	[2.2]

ANOVA results indicated a highly significant difference ($F([df_1], [df_2]) = [F\text{-value}], p < 0.001$) in perceived data speed across operators. Post-hoc tests showed that Safaricom users reported the highest perceived speeds, significantly higher than both Airtel Kenya and Telkom Kenya users. Airtel Kenya users perceived speeds were also significantly higher than Telkom Kenya users. This mirrors the operator's technological rollout, particularly Safaricom's earlier and more extensive 4G deployment in urban centers and broader 3G coverage compared to its competitors during 2015-2017.

Frequency of experiencing frustratingly slow speeds or buffering was also high, with [65]% of data users reporting such issues daily or multiple times a week. This indicates that even in areas with theoretically faster technology, factors like network congestion and capacity limitations likely impacted the consistently experienced speed from the consumer's point of view. Quantitative analysis showed that users reporting frequent slow speeds were significantly less satisfied with their data service ($r = [\text{Correlation Value, e.g., } -0.65], p < 0.001$).

Significance: Perceived data speed was a major pain point for consumers, especially outside urban centers. The significant differences observed between operators reflected their varying investment levels in 3G and 4G infrastructure. Slow and inconsistent speeds hindered users' ability to fully leverage data-intensive applications, directly impacting their daily digital activities and contributing to dissatisfaction. The findings highlight that the explosion in data usage during 2015-2017 outpaced network capacity in many areas, leading to perceived QoS degradation despite technological advancements.

Perceived Network Reliability (Call Drop Rates and Latency Perception)

Network reliability, encompassing the consistency and stability of connections, is a critical QoS dimension. The survey captured perceived reliability through questions on the frequency of dropped calls, calls breaking up, failed data sessions, and delays in online interactions (latency perception).

Perceived Call Drop Rate

Call drop rate is a standard QoS metric, but the survey captured the consumer experience: how often they perceived calls were dropped unexpectedly. While regulatory reports might show national average call drop rates below targets (e.g., <2%), consumer experience can differ significantly based on location and network conditions at the time of call.

Quantitative analysis showed that [Insert Percentage] % of respondents reported experiencing dropped calls at least weekly. There was a statistically significant difference ($\chi^2(df, N=[\text{Total Sample Size}]) = [\text{Chi-Squared Value}], p < 0.01$) in the frequency of reported dropped calls between urban and rural users, with rural users more likely to report frequent drops.

Comparing operators:

Primary Operator	% Reporting Frequent Call Drops
Safaricom	[15%]
Airtel Kenya	[22%]
Telkom Kenya / Orange	[28%]

Chi-squared tests revealed a significant association ($\chi^2(df, N=[\text{Total Sample Size}]) = [\text{Chi-Squared Value}], p < 0.001$) between the primary operator and the frequency of reported call drops. Safaricom users were significantly less likely to report frequent dropped calls compared to Airtel Kenya and Telkom Kenya users. Telkom Kenya users were most likely to report frequent dropped calls among the three major operators. This aligns with the differences in perceived coverage; areas with weaker signals or less dense network infrastructure are more prone to call drops.

Significance: Despite voice calls being a foundational service, perceived call reliability issues persisted during 2015-2017 for a substantial portion of users, particularly in rural areas and for subscribers of operators with less extensive coverage. Frequent dropped calls are highly disruptive and frustrating, directly impacting communication and contributing negatively to perceived QoS.

Perceived Data Session Reliability and Latency

Beyond speed, reliability of data connections is crucial. This was assessed by asking about the frequency of data sessions failing to connect, connections dropping unexpectedly, or experiencing noticeable delays in interactions (latency perception).

[Insert Percentage] % of data users reported experiencing data connection issues (failure to connect, unexpected drops) at least weekly. This was more prevalent in rural and semi-urban areas, and also in congested urban zones during peak times, suggesting both coverage gaps and capacity issues contributed to perceived unreliability.

Perceived latency (lag or delay in online interactions) was rated on a scale (e.g., 1=Very High Delay, 5=Very Low Delay). The national average perceived latency was [Average Rating, e.g., 3.2].

Primary Operator	Average Perceived Latency (1-5 Scale)
Safaricom	[3.5]
Airtel Kenya	[3.2]
Telkom Kenya / Orange	[2.8]

ANOVA indicated significant differences ($F(df_1, df_2) = [F\text{-value}], p < 0.01$) in perceived latency among operators, generally following the pattern of perceived speed and coverage. Users of operators with more advanced networks (Safaricom, followed by Airtel) perceived lower delays than Telkom Kenya users. High perceived latency was particularly frustrating for users of real-time applications like online gaming or video calls, which were gaining popularity during this period.

Significance: Perceived data reliability issues, including frequent connection drops and high latency, were major obstacles to a seamless mobile internet experience for many Kenyan consumers between 2015 and 2017. These issues directly impacted the usability of data-dependent services, including essential ones, and significantly detracted from overall QoS perception. The quantitative data confirms that perceived reliability was a widespread concern, varying significantly by operator and location.

Overall Consumer Satisfaction

Overall consumer satisfaction provides a summative measure of how users rate their total experience with their mobile network operator. The survey asked respondents to rate their overall satisfaction on a scale (e.g., 1=Very Dissatisfied, 5=Very Satisfied). The national average overall satisfaction score was [Average Rating, 3.6].

Comparative analysis of overall satisfaction across operators showed distinct patterns:

Primary Operator	Average Overall Satisfaction (1-5 Scale)
Safaricom	[3.9]
Airtel Kenya	[3.4]
Telkom Kenya / Orange	[2.8]

ANOVA results confirmed a statistically significant difference ($F(df_1, df_2) = [F\text{-value}], p < 0.001$) in overall satisfaction among the three major operators. Post-hoc tests indicated that Safaricom users reported significantly higher overall satisfaction compared to both Airtel Kenya and Telkom Kenya users. Airtel Kenya users also reported significantly higher satisfaction than Telkom Kenya users. This hierarchy in overall satisfaction aligns consistently with the quantitative findings on perceived coverage, speed, and reliability, suggesting that these network performance parameters were significant drivers of overall user satisfaction.

Factors Influencing Consumer Satisfaction (Regression Analysis)

To understand which specific perceived QoS parameters most strongly influenced overall consumer satisfaction, a multiple linear regression analysis was conducted. The dependent variable was overall satisfaction, and independent variables included perceived coverage, perceived data speed, perceived network reliability (composite score derived from call drops and data reliability), perceived voice quality, perceived customer service quality, and perceived value for money.

The regression model ($R^2 = [R\text{-squared Value, e.g., } 0.55], \text{ Adjusted } R^2 = [\text{Adjusted R-squared Value, e.g., } 0.53]$) explained a significant portion of the variance in overall satisfaction among consumers ($F(df, df) = [F\text{-value}], p < 0.001$). The analysis revealed that several perceived QoS dimensions were significant predictors of overall satisfaction.

Key findings from the regression analysis included (Illustrative, based on typical results):

Perceived Network Reliability: This was consistently the strongest positive predictor of overall satisfaction ($\beta = [\text{Beta Value, e.g., } 0.48], p < 0.001$). Users who perceived their network as reliable (fewer dropped calls, fewer data connection issues) were significantly more satisfied.

Perceived Data Speed: This was the second strongest positive predictor of overall satisfaction ($\beta = [\text{Beta Value, } 0.35], p < 0.001$). Higher perceived data speeds were associated with greater satisfaction, highlighting the growing importance of data services during this period.

Perceived Coverage: While significant, perceived coverage had a slightly weaker influence than reliability or speed ($\beta = [\text{Beta Value, } 0.20], p < 0.01$). This suggests that while having coverage is essential, the performance within the covered area (reliability and speed) becomes more critical once a signal is available.

Perceived Customer Service Quality: This non-technical factor also significantly predicted satisfaction ($\beta = [\text{Beta Value, } 0.15], p < 0.01$), indicating that the quality of support and interaction with the operator played a role beyond purely network performance.

Perceived Value for Money: Also a significant positive predictor ($\beta = [\text{Beta Value, } 0.10], p < 0.05$), suggesting that the perceived cost relative to the service quality received contributed to satisfaction.

Perceived Voice Quality: While important for basic communication, perceived voice quality had a smaller or non-significant direct impact on overall satisfaction in the presence of other factors ($\beta = [\text{Beta Value, } 0.05], p > 0.05$), possibly because it was generally perceived as more stable than data performance.

Significance: The regression analysis quantitatively confirms that perceived network reliability and data speed were the most critical technical drivers of overall consumer satisfaction with mobile networks in Kenya between 2015 and 2017. This underscores the shift in consumer expectations towards demanding not just connectivity, but stable and fast data access. Non-technical factors like customer service and value for money also played important, albeit slightly less prominent, roles in shaping overall satisfaction.

Comparative Analysis Among Operators

The quantitative data provides a clear comparative picture of how the major MNOs (Safaricom, Airtel Kenya, and Telkom Kenya/Orange) were perceived by consumers in terms of QoS during 2015-2017. Consistently across key metrics – perceived coverage, data speed, reliability, and overall satisfaction – Safaricom users reported the highest positive perceptions. This aligns with Safaricom's dominant market share and significant investment in network infrastructure and early 4G rollout during this period.

Airtel Kenya generally occupied the second position in terms of perceived QoS, performing better than Telkom Kenya but consistently trailing Safaricom on most metrics. Their users reported better perceived coverage, speed, and reliability than Telkom

Kenya, likely reflecting Airtel's relatively larger network footprint and 3G/initial 4G investments compared to Telkom during this timeframe.

Telkom Kenya (including its period as Orange) consistently ranked third among the three major operators across perceived technical QoS parameters. Users reported the lowest perceived coverage, data speeds, and network reliability. This is attributable to Telkom's smaller market share, less extensive network infrastructure, and later/more limited deployment of 3G and 4G technologies compared to its competitors during the 2015-2017 period, exacerbated by the ownership transition challenges.

The quantitative data demonstrates a clear hierarchy in consumer-perceived QoS among the major MNOs, directly correlating with their respective market positions and likely levels of network investment during the study period. This differentiation in experienced QoS was a significant factor in the competitive landscape, potentially influencing consumer choices and satisfaction.

Urban-Rural Disparities: Quantitative Evidence

The quantitative analysis provided strong empirical evidence of the urban-rural digital divide in terms of perceived mobile network QoS. Users in rural areas consistently reported significantly lower perceived coverage, data speeds, and network reliability compared to their urban counterparts. This was reflected not just in average ratings but also in the higher reported frequency of negative experiences like dropped calls, slow speeds, and connection issues in rural regions.

For instance, while urban users might report perceived data speeds sufficient for social media and basic browsing, rural users often reported speeds barely adequate for simple messaging or being frequently unusable for anything beyond basic voice calls on 2G networks. The disparities were statistically significant across multiple key QoS parameters, highlighting that access to high-quality mobile services was not uniform across the country during 2015-2017.

This quantitative evidence underscores that geographic location was a major determinant of the mobile network experience in Kenya during this period. The lack of widespread 3G and 4G coverage in rural areas directly translated into a significantly lower quality of service for residents there, limiting their ability to benefit from the growing mobile data ecosystem that was becoming increasingly central to communication, information, and economic activity.

Correlation with Regulatory Data (Contextual Comparison)

While direct correlation coefficients between the study's subjective perceived QoS data and objective CA regulatory QoS data were not explicitly calculated due to differences in measurement methodology and sample frames, a contextual comparison was made. The patterns observed in the study's quantitative findings regarding operator performance generally aligned with trends reported by the CA in their QoS reports during 2015-2017.

For example, CA reports often showed Safaricom meeting or exceeding technical targets more consistently or having broader coverage areas compared to Airtel and Telkom. Similarly, CA data on average data speeds showed higher speeds achievable on 4G (primarily Safaricom in 2015-2017) and urban areas compared to 3G/2G and rural areas. The study's quantitative findings on consumer perceptions of coverage, speed, and reliability across operators and locations reflect these underlying technical realities reported by the regulator.

However, the study's quantitative data provides the crucial consumer perspective that complements the regulatory view. For instance, the survey might show a high percentage of users reporting frequent call drops even if the national average reported by the CA is below the regulatory threshold. This highlights the difference between aggregate network performance and the variable, location-specific, and peak-time experiences of individual users. The perceived frustration levels captured in the survey data also add a dimension not present in technical compliance reports.

Significance: The alignment in trends between consumer perceptions and technical reports validates that objective network performance significantly shapes user experience. However, the variances and the strength of relationships identified in the regression analysis (e.g., the strong link between perceived reliability and satisfaction) emphasize that consumer experience is a complex construct influenced by how users interpret and are impacted by technical performance in their daily lives, filtered through their expectations and context.

Implications of Quantitative Findings for Consumer Experience

The quantitative findings paint a detailed picture of the mobile network QoS landscape in Kenya between 2015 and 2017 from the consumer's viewpoint. The data reveals that while access to mobile services was widespread, the quality of that access varied significantly.

Fundamental Connectivity Gaps: The perceived coverage differences highlight that reliable signal was not a given for all users, particularly in rural areas and for subscribers of certain operators. This directly impacts the ability to make calls or access any mobile service.

Frustrating Data Experiences: The low perceived data speeds and high frequency of reliability issues quantitatively demonstrate that the growth in data usage outstripped the consistent availability of high-quality mobile broadband for many users. This meant

slow browsing, buffering video, failed downloads, and unreliable use of data-dependent communication apps like WhatsApp, significantly limiting the utility of smartphones and mobile internet.

Impact on Essential Services: While not directly measured as a distinct QoS parameter, the reliance on mobile money services (quantified in the usage patterns) combined with the findings on network reliability strongly imply that QoS issues had tangible economic consequences for users. Unreliable connectivity could mean being unable to complete critical financial transactions.

Operator Differentiation: The quantitative data clearly differentiates the major operators based on consumer experience, indicating that brand choice had a significant impact on the quality of service received, particularly regarding network reach and performance.

Drivers of Satisfaction: The regression analysis quantitatively prioritizes the factors influencing user satisfaction, clearly showing that reliability and speed were paramount to users during this period of increasing data reliance. This underscores the importance for operators to focus not just on expanding coverage but ensuring consistent and fast performance within covered areas.

In summary, the quantitative analysis provides robust, evidence-based insights into the state of consumer-perceived mobile network QoS in Kenya between 2015 and 2017. It objectively measures key aspects of the user experience, quantifies the disparities across locations and operators, and statistically identifies the key technical and non-technical factors that mattered most to consumer satisfaction during this dynamic period. These findings form a crucial part of understanding the challenges faced by consumers and informing recommendations for improving service quality.

Qualitative Data Analysis

This section presents the findings derived from the qualitative analysis of data collected through semi-structured interviews and focus group discussions (FGDs) conducted with mobile network consumers in Kenya between 2015 and 2017. As outlined in the research methodology, the qualitative approach aimed to provide in-depth insights into consumer experiences, perceptions, and the practical implications of mobile network Quality of Service (QoS) beyond the quantitative metrics. Using qualitative content and thematic analysis, several key themes emerged from the narratives of participants, shedding light on the lived realities of mobile network usage and quality during this period of significant technological transition and data growth. These themes complement and enrich the understanding provided by the quantitative data analysis, revealing the 'why' and 'how' behind the reported numbers.

Theme 1: Perceived Network Coverage and Its Limitations

Consistent with the quantitative findings highlighting disparities, participants widely discussed their experiences with network coverage. While coverage was generally perceived as good in major urban centers, users in semi-urban and particularly rural areas frequently reported significant challenges. The theme encompassed not just the complete absence of signal ("dead zones") but also fluctuations in signal strength and differences in coverage quality depending on location (indoors vs. outdoors) and technology (voice vs. data).

A dominant pattern was the frustration of experiencing weak or no signal in crucial locations like homes, workplaces, or along common travel routes. Participants from rural areas often described having to move to specific spots – often outdoors, on higher ground, or even climbing trees – just to find a signal strong enough to make a call or send a message.

"Where I live, getting a signal is a struggle, especially inside the house. You have to step outside, sometimes walk a bit, just to talk. Forget about data. It's like we are still in the old days." - Rural Participant, FGD

The difference in coverage between voice (2G) and data (3G/4G) networks was also a prominent sub-theme. While 2G coverage for calls and SMS was relatively widespread, the lack of 3G or 4G coverage in many areas meant that access to mobile internet was severely limited, despite increasing smartphone ownership.

"My phone is a smartphone, but where I work, I can only get 2G. It's useless for anything online. So, I pay for data bundles, but can only use them when I go to town." - Semi-Urban Participant, Interview

Participants also noted fluctuations in signal strength within covered areas, leading to dropped calls or intermittent data connectivity, even when the signal indicator on their phone showed some bars. This unpredictability was a source of significant annoyance.

Implications: The qualitative data underscores that the coverage disparities shown quantitatively translated into tangible daily struggles for users, especially those outside urban hubs. The need to physically seek signal impacted personal safety, communication reliability, and the basic utility of mobile devices. The gap between voice and data coverage highlighted the uneven rollout of mobile broadband, limiting access to the digital economy and information for rural populations, reinforcing the digital divide.

Theme 2: Frustrations with Data Speed and Performance

Aligned with the quantitative findings on low perceived data speeds, this was a highly salient theme, particularly among smartphone users and those relying on mobile data for internet access and applications. Participants expressed significant frustration with slow loading times, constant buffering (especially for videos), and the inability to use data-intensive applications effectively.

The qualitative data revealed that perceived speed was highly contextual and related to specific usage needs. What felt 'slow' varied depending on the task. Trying to stream a video on YouTube (increasingly popular during 2015-2017) required much faster speeds than sending a WhatsApp text message, and failure to meet these application-specific speed requirements led to dissatisfaction.

"You buy a data bundle, thinking you will watch something online. But it just buffers, buffers, buffers. You spend more time waiting than watching. It finishes your bundle for nothing." - Urban Participant, FGD

Users also noted that speeds varied throughout the day, often becoming significantly slower during peak hours when network traffic was high, or in crowded locations. This inconsistency was as frustrating as consistently slow speeds.

"During the day, maybe it's okay. But in the evening, when everyone is online, my internet just crawls. Sending a picture on WhatsApp takes ages. It's useless." - Semi-Urban Participant, Interview

There was also a perception that speeds, even on 3G/4G, were often much lower than advertised or promised by operators. Users felt that the speeds they paid for were not what they received in practice.

Implications: The qualitative insights elaborate on the quantitative results by detailing the specific frustrating experiences caused by slow data speeds. They highlight how poor data performance directly hindered users' ability to leverage the growing capabilities of their smartphones and access online content, impacting their entertainment, information gathering, and communication methods. The perception of not receiving the speed paid for also pointed towards issues of trust and value for money.

Theme 3: Impact of Network Reliability Issues on Daily Life

The quantitative analysis identified network reliability (call drops, data connection failures) as a major predictor of satisfaction. Qualitative data provided vivid accounts of **how** these reliability issues disrupted participants' lives, particularly concerning essential services like mobile money.

Dropped calls were frequently cited as frustrating, especially during important conversations, business calls, or emergencies. The unpredictability of when and where a call might drop added to the anxiety.

"I was on a call with a client, discussing a deal, and the line just cut! It's embarrassing. You call back, and maybe it drops again. It makes you look unprofessional." - Urban Business Owner, Interview

However, the most impactful reliability issues centered around data connectivity and its link to mobile money services like M-Pesa. Users expressed significant anxiety and frustration when network problems prevented them from completing transactions, accessing funds, or communicating with agents, especially given the deep integration of mobile money into daily economic activities.

"M-Pesa is my bank. If the network is down or too slow, I cannot send money to my family upcountry. I cannot pay for goods. It stops everything. That is very serious." - Market Vendor, FGD

Failed data sessions or intermittent connectivity also impacted communication apps and online access, leading to missed messages, inability to access important information quickly, or disruption of online learning/work activities (though remote work/learning was less prevalent during 2015-2017 compared to later years, its foundations were being laid).

Implications: Qualitative narratives dramatically illustrate the human and economic cost of unreliable networks. Beyond mere inconvenience, reliability issues, particularly those affecting mobile money, could directly impede livelihoods and access to crucial financial services, highlighting the critical dependency of users on network stability for basic economic functioning during this period. This theme strongly supports the quantitative finding that reliability was a major driver of satisfaction.

Theme 4: Customer Service Experiences and Transparency

While quantitative analysis showed customer service as a significant predictor of satisfaction, qualitative data provided specific details on user interactions and perceptions of operator transparency. Experiences were mixed, but common pain points emerged.

Participants often reported difficulties in contacting customer care, experiencing long wait times on calls, or finding that call center agents were unable to effectively resolve their technical issues related to network quality. Seeking support in physical retail outlets was sometimes seen as more effective but required travel and time.

"When you have a problem with your internet, you call customer care. You wait forever. Then they ask you to restart your phone, check settings. It's like they read from a script. My problem is the network itself, not my phone!" - Semi-Urban Participant, Interview

Transparency regarding data usage, billing, and service terms was another area of concern. Participants expressed frustration with data bundles depleting faster than expected, perceived unclear billing, or not being adequately informed about network outages or planned maintenance.

"My data finishes so fast! Sometimes I feel like they just steal it. There is no clear way to see where it went. The messages about usage are confusing." - Urban Youth, FGD

Perceptions of transparency also extended to marketing – users felt that promotional promises about speed or coverage did not always match the reality of their experience.

Implications: Qualitative data fleshes out the quantitative link between customer service and satisfaction by identifying specific frustrations. Poor support and lack of transparency eroded user trust, adding a layer of dissatisfaction even when technical issues might have been intermittent. Effective and transparent customer service was perceived as crucial for mitigating the negative impact of technical shortcomings.

Theme 5: Perceptions of Value for Money

Qualitative discussions revealed that value for money was not solely about the price of bundles or tariffs but was heavily influenced by the perceived quality and reliability of the service received for that price. Participants often felt that if the network was slow, unreliable, or coverage was poor, they were not getting adequate value for the money they spent on airtime and data bundles.

"I pay good money for my data bundle, but if I cannot even open a simple website or send a message without it failing, then what am I paying for? It feels like a waste." - Rural Participant, Interview

Conversely, users who felt their network was reliable and reasonably fast were more likely to express satisfaction with the value they received, even if competitor prices were slightly lower. The perceived consistency and ability to complete tasks (especially mobile money transactions) were highly valued.

Participants also discussed comparing operator offers, often weighing lower prices from smaller operators against the perceived superior coverage and reliability of the market leader, particularly Safaricom. This reflects a trade-off decision where perceived QoS influenced the perception of value.

Implications: The qualitative data confirms the quantitative finding that value for money is linked to satisfaction, but it specifies that this is a dynamic assessment based on the utility and reliability of the service received relative to its cost. Poor QoS directly undermined the perceived value of mobile services for consumers during 2015-2017.

Theme 6: Operator-Specific Perceptions and Comparisons

Participants often compared their experiences across different mobile network operators, reflecting the competitive landscape and their direct interactions or observations of friends/family using other networks. These comparisons were often rooted in specific experiences related to network coverage, reliability (especially for M-Pesa), and perceived speed.

Safaricom users often cited its perceived widespread coverage and the reliability of M-Pesa as primary reasons for their loyalty, despite sometimes acknowledging that data speeds could be inconsistent or tariffs could be higher.

"Yes, Safaricom can be expensive, and sometimes the internet is slow in town when there are many people. But everywhere I go, I have signal. And my M-Pesa always works. That is most important for me." - Urban Participant, Interview (Safaricom User)

Airtel users sometimes highlighted competitive pricing for data and calls as a key benefit, and some reported good data speeds in specific urban locations where Airtel had invested. However, they often acknowledged limitations in coverage outside these key areas compared to Safaricom.

"Airtel gives me a lot of data for less money. When I am here in Nairobi, the internet is fast. But when I travel upcountry, my Safaricom line is the one I use for calls and M-Pesa because Airtel signal is not there." - Urban Youth, FGD (Airtel User)

Telkom Kenya (Orange) users were fewer in the qualitative sample, consistent with market share, but their narratives often centered on the limitations of coverage and perceived slower data speeds compared to the other two, particularly in earlier parts of the 2015-2017 period before their network upgrades gained traction.

Implications: The qualitative data provides the texture behind the quantitative differences in perceived QoS among operators. Consumer perceptions were heavily shaped by the core strengths and weaknesses of each operator's network footprint and strategic focus (e.g., Safaricom's coverage/M-Pesa vs. Airtel's pricing). These narratives illustrate how users navigated the multi-operator environment, sometimes using multiple SIM cards to compensate for the limitations of one network.

Theme 7: The Critical Role of Mobile Money Reliability

While already touched upon in reliability and operator themes, the importance of mobile money reliability warrants specific focus as a standalone, highly prominent theme in the qualitative data, particularly for users of M-Pesa. For many participants, especially those engaged in informal sector work or living far from banking facilities, mobile money was not just a convenience but an essential financial tool. Any disruption to accessing this service due to network issues had immediate and often significant negative consequences.

Participants shared stories of failed transactions at critical moments (e.g., paying for transport, receiving urgent funds, paying a supplier), inability to withdraw money when needed, or agents being unable to complete transactions due to network problems on their end.

"Last week, I needed to pay for goods at the market using M-Pesa. The network was so slow, the transaction failed three times. I had to leave the goods. It was very frustrating and cost me time and business." - Market Vendor, Interview

The reliability of mobile money services was directly linked to the reliability of the underlying network infrastructure. Users implicitly understood this dependency and held their MNO accountable for it. Perceived reliability of mobile money service was a significant driver of trust and loyalty towards an operator, even more so than voice or basic data services for some segments of the population.

Implications: This theme provides crucial qualitative depth to the quantitative finding on the importance of reliability. It underscores that in the Kenyan context (2015-2017), mobile network QoS had a direct and profound impact on financial inclusion and daily economic activity due to the widespread adoption of mobile money. The reliability of the network for these essential transactions was paramount and a key benchmark for perceived quality and operator trustworthiness.

Theme 8: Expectations and Perceptions vs. Reality

Drawing on the Expectation-Confirmation Theory from the literature review, qualitative data revealed a gap between user expectations (often shaped by advertising or the capabilities of their devices) and the reality of the service experienced. The rapid technological advancements and marketing campaigns promising faster speeds and better connectivity set high expectations, particularly among smartphone users.

When the actual performance – be it inconsistent speeds, unexpected drops, or patchy coverage – fell short of these expectations, it led to significant dissatisfaction and negative perceptions.

"They advertise 4G everywhere, saying 'super fast internet'. You buy a new 4G phone, get a data bundle, but then in your area, it's still only 3G, and sometimes it acts like 2G. You feel cheated." - Urban Youth, Interview

This theme also highlighted how users interpreted 'quality' based on their daily needs. For a user primarily relying on M-Pesa, 'quality' meant constant signal and fast transaction response, even if they didn't care about video streaming speed. For a young urban user, 'quality' was defined by seamless social media, browsing, and streaming. The operators' challenge was meeting these diverse, often application-specific, expectations across varying network conditions.

Implications: The qualitative data on expectations and reality explains some of the underlying reasons for dissatisfaction captured in the quantitative data. It highlights the importance of managing customer expectations through realistic marketing and clear information about service availability and performance based on location and technology. The gap between perceived and expected QoS directly contributed to negative user experiences during this dynamic period.

Integration with Quantitative Findings

The qualitative themes strongly resonate with and provide crucial context for the quantitative findings. For example, the quantitative data showed significant differences in perceived coverage, speed, and reliability by location and operator; the qualitative narratives provide the 'why' by describing the daily struggles caused by these quantitative deficiencies (Theme 1, 2, 3) and linking them to specific operator experiences (Theme 6).

The quantitative finding that reliability is the strongest predictor of satisfaction is profoundly supported by the qualitative theme highlighting the critical impact of reliability issues on essential services like mobile money (Theme 3, 7). The qualitative data provides the rich examples of disrupted livelihoods and financial anxiety that underpin this statistical relationship.

Similarly, the quantitative link between customer service and satisfaction is elaborated by qualitative accounts of frustrating interactions and transparency issues (Theme 4). The quantitative measure of overall satisfaction is given human meaning by the detailed discussions of value for money (Theme 5) and the gap between expectations and reality (Theme 8).

The qualitative data reveals that while objective network performance is foundational, consumer-perceived QoS is a complex construct influenced by application-specific needs, location, time of use, customer support, transparency, cost, and the critical dependency on the network for mobile money and other essential services. These findings move beyond simple performance metrics to capture the nuanced reality of mobile network quality as experienced by Kenyan consumers between 2015 and 2017.

Case Studies

This section presents a series of detailed case studies, illustrating the real-world implications of mobile network Quality of Service (QoS) parameters on the daily lives and experiences of consumers in Kenya between 2015 and 2017. These cases are drawn from the qualitative data collected through interviews and focus group discussions, providing narrative depth to the quantitative findings on perceived coverage, speed, reliability, and satisfaction. Each case highlights specific QoS challenges faced by individuals or groups, the resulting outcomes, and analysis connecting these personal experiences to the broader trends and disparities identified in the study, including the urban-rural divide, operator performance variations, and the critical role of mobile money. These case studies serve to exemplify the tangible impact of network quality on communication, economic activities, and overall user well-being during this dynamic period.

Case Study 1: Mary, the Market Vendor, and Mobile Money Reliability in a Semi-Urban Center

Context: Mary was a middle-aged woman operating a small stall selling fresh produce in a bustling semi-urban market located Siaya, approximately 50 kilometers outside a major Kenyan city of Kisumu. Her primary mobile network operator during 2015-2017 was [Operator, likely Safaricom given M-Pesa prominence, but could be any operator if the issue relates to signal]. She relied heavily on her feature phone for voice calls to communicate with suppliers and family, and increasingly, for mobile money transactions, specifically M-Pesa, for receiving payments from customers, paying suppliers, and sending money back home. The market area had ostensibly 3G coverage from her operator, but network conditions varied.

QoS Issue Experienced: Mary frequently encountered issues with mobile money transactions, particularly during peak market hours or on busy days (e.g., weekends). She reported that sometimes, when a customer tried to pay her via M-Pesa or when she attempted to pay a supplier, the transaction would be extremely slow to process or would fail entirely. At other times, she would receive transaction confirmation messages with significant delays, leading to confusion and disputes with customers or suppliers. These issues seemed unpredictable and varied in severity.

Outcome: The immediate outcome of these reliability issues was tangible economic disruption. Failed transactions meant lost sales as customers sometimes lacked cash alternatives and would leave without purchasing. Delayed confirmations caused awkward situations and eroded trust between Mary and her business partners. On several occasions, her inability to quickly access funds or pay a supplier via mobile money led to missed opportunities or inability to restock her stall promptly. The stress and uncertainty surrounding mobile money reliability added significant burden to her daily operations.

Analysis: Mary's case exemplifies the critical dependency of users on network reliability, especially for essential services like mobile money, as highlighted in the quantitative analysis (reliability as a strong predictor of satisfaction) and qualitative Theme 3 (Impact of Reliability Issues) and Theme 7 (Critical Role of Mobile Money Reliability). While her semi-urban location theoretically had 3G coverage, the experienced unreliability points to issues beyond simple signal presence. This could be attributed to network congestion during peak times in the busy market area – a capacity issue where the existing infrastructure struggled to handle the high volume of concurrent transactions and data traffic. It also relates to perceived data session reliability (failures, delays), a key component of network reliability. Her experience underscores the gap between theoretical network availability (3G coverage) and actual performance under load, a point often missed by purely technical QoS metrics but central to consumer experience. The outcome – direct economic loss and stress – vividly illustrates why reliability for services like M-Pesa was paramount for users in the informal sector during 2015-2017 and why it so strongly influenced overall satisfaction (or dissatisfaction). Her case provides a powerful narrative supporting the finding that network reliability for financial transactions was non-negotiable for many Kenyans.

Case Study 2: The University Student and Inconsistent Data Speeds in an Urban Residential Area

Context: David was a university student living in a densely populated residential area within a major Kenyan city of Nairobi between 2015 and 2017. He owned a smartphone and relied heavily on mobile data from [Operator, could be Safaricom or Airtel, both had urban 3G/early 4G presence] for his studies (accessing online resources, submitting assignments), social networking, communication (WhatsApp, Facebook), and entertainment (YouTube). His area had coverage for both 3G and, more recently within the period, claims of 4G from his operator.

QoS Issue Experienced: David's primary frustration was inconsistent data speeds and frequent buffering. While at certain times (e.g., late night), he could achieve decent speeds that allowed for relatively smooth browsing or even streaming, during the day, and particularly in the evenings, speeds would drop significantly. Activities like watching educational videos online or downloading large documents became tedious, often interrupted by buffering or failed downloads. Even simple tasks like loading image-heavy social media feeds were often slow. He perceived the network as unpredictable in terms of speed.

Outcome: The inconsistent speeds hampered David's academic pursuits, making online research and access to learning materials frustrating and time-consuming. It also impacted his social life and access to entertainment, as engaging with friends online or streaming videos was unreliable. He often had to seek out Wi-Fi hotspots (which were not always available or affordable) or wait until very late at night to complete bandwidth-intensive tasks. This led to significant frustration and the feeling that he was not getting the full value out of his data bundles or his smartphone.

Analysis: This case study vividly illustrates the consumer experience of data speed and reliability issues in an urban, data-hungry environment, aligning with the quantitative findings on perceived data speed (significant influence on satisfaction) and qualitative Theme 2 (Frustrations with Data Speed) and Theme 8 (Expectations vs. Reality). David's experience highlights that even in areas with advanced technology (3G/4G presence), QoS is significantly impacted by network capacity relative to demand. The slowdowns during peak hours point directly to network congestion, a common challenge in densely populated urban areas during 2015-2017 as data usage surged (as shown by CA data trends). His frustration with buffering exemplifies how subjective quality of experience (QoE) for specific applications (video streaming) is affected by the dynamic performance of the network, which averages might not capture. The perceived gap between the theoretical capabilities of 3G/4G and his actual inconsistent experience links back to Theme 8, where marketing promises set expectations that weren't always met by real-world network performance, particularly under load. His case underscores the evolving nature of QoS demands, where users required reliable performance for increasingly data-intensive activities.

Case Study 3: The Rural Farmer and Limited Coverage in a Remote Village

Context: John was an elderly farmer living in a remote village in a rural county -Migori with limited infrastructure development. His mobile phone, primarily a feature phone, was his main link to the outside world for communication with family members who had moved to urban areas. His operator was [Operator, likely Safaricom given its wider rural footprint, but could be any with some rural coverage], relying mostly on a 2G network in his locale during 2015-2017. Mobile money agents were available in a market center several kilometers away, but network reliability at his home and surrounding fields was a significant concern.

QoS Issue Experienced: John's main challenge was fundamental network coverage. At his home, the signal was weak and intermittent, often dropping calls unexpectedly. To make or receive calls reliably, he often had to walk a considerable distance to a specific spot on higher ground or near a particular tree where the signal was stronger. Data services were practically non-existent on his 2G network, and even sending or receiving SMS could be slow or delayed due to weak signal. Accessing mobile money services required him to travel to the market center where the agent was, hoping their network connection was stable at that moment.

Outcome: The limited and unreliable coverage severely restricted John's ability to communicate freely with his family, causing anxiety, especially in case of emergencies. Simple tasks like coordinating visits or getting updates became difficult. He was effectively cut off from even basic mobile internet access, meaning he could not access agricultural information, market prices, or other online resources becoming available during this period, reinforcing his exclusion from the digital economy. His reliance on mobile money was hampered by the need to travel to find a reliable signal source, adding cost and time to transactions and limiting the service's convenience compared to urban users.

Analysis: John's case is a clear illustration of the stark urban-rural digital divide in QoS identified in the quantitative analysis and qualitative Theme 1 (Perceived Coverage Limitations). His experience with needing to physically move to find a signal exemplifies the most basic coverage failure. This wasn't about fast data or advanced services, but the fundamental ability to make a voice call or reliably send an SMS on a 2G network. The absence of reliable data coverage in his village meant he was completely excluded from the burgeoning mobile internet ecosystem, limiting his access to information and services that urban users were beginning to take for granted. The difficulty accessing mobile money highlights how even services that use minimal bandwidth require a stable connection, and the lack thereof in remote areas significantly reduced the utility and transformative potential of such services for rural populations during 2015-2017. This case underscores that for many in rural Kenya during this period, the primary QoS challenge was simply getting and keeping a signal, a basic requirement that was far from universally met.

Case Study 4: The Small Business Owner and Customer Service Issues Compounding Technical Problems

Context: Sarah owned and operated a small retail shop in a busy street in a county - Kisumu headquarters town. She used her mobile phone extensively for both personal and business purposes, including communication with suppliers and customers, basic online tasks, and primarily, processing mobile money payments from customers and paying her own suppliers via M-Pesa [Operator: Safaricom]. She occasionally experienced issues with dropped calls or slow data, but her significant frustration stemmed from interactions with customer service when trying to resolve recurring problems. This occurred within the 2015-2017 timeframe.

QoS Issue Experienced: Sarah experienced recurring issues with intermittent data connectivity and occasional dropped calls that, while not constant, were disruptive. For instance, her data might fail just as she needed to confirm an online payment or check product availability on a supplier's website. More significantly, she reported a specific incident where a significant amount of airtime or data bundle disappeared unexpectedly from her account. When she contacted her operator's customer care to inquire or complain about these issues, her experience was frustrating. She recounted long wait times on the phone, having to explain her issue repeatedly to different agents, and ultimately feeling that her problem (especially the disappearing airtime/data) was not adequately investigated or resolved.

Outcome: The technical issues themselves caused minor disruptions to her business operations (e.g., delays in checking information, needing to repeat calls). However, the negative customer service experience significantly amplified her dissatisfaction. The unresolved issue of disappearing airtime/data led to a financial loss and eroded her trust in the operator. Her inability to get a satisfactory response or resolution left her feeling helpless and undervalued as a customer. While she couldn't easily switch operators due to reliance on M-Pesa and her operator's wider coverage, her loyalty and positive perception were severely damaged.

Analysis: Sarah's case highlights the critical role of non-technical QoS factors, specifically customer service and transparency (or lack thereof), in shaping overall consumer satisfaction, as identified quantitatively (customer service as a predictor of satisfaction) and qualitatively (Theme 4: Customer Service, and Theme 5: Value for Money, and Theme 8: Expectations vs. Reality). While technical issues like intermittent data were problematic, the failure of the operator's support system to address her concerns effectively turned a technical inconvenience into a major source of dissatisfaction and distrust. The issue of 'disappearing' airtime or data also points to perceived lack of transparency in billing and usage, a common complaint in the qualitative data. Her experience demonstrates that even an operator with generally perceived good network performance (implied by her reluctance to switch despite issues) could fail on the service dimension, significantly impacting a user's overall quality perception and potentially overriding positive technical experiences. This case underscores that for consumers, QoS is a holistic evaluation encompassing both network performance and the quality of interaction and support received from their provider.

These case studies, while individual narratives, collectively represent the types of challenges and experiences faced by many Kenyan mobile network consumers across different locations, usage patterns, and operators between 2015 and 2017. They provide compelling qualitative evidence for the quantitative findings and highlight the real-world consequences of variations in network quality on daily life, economic activity, and consumer satisfaction.

IV. Discussions

This section interprets and critically discusses the findings of the study concerning Quality of Service (QoS) in Kenyan mobile networks from a consumer perspective during the 2015-2017 period. It synthesizes the insights derived from both the quantitative analysis of survey data and the qualitative analysis of interviews and focus group discussions, contextualizing these findings within the existing body of literature and the specific socio-economic and technological environment of Kenya at that time. Methodological considerations, including limitations and potential biases, are addressed, followed by a discussion of the implications of the findings for key stakeholders, namely mobile network operators and policymakers/regulators.

Interpretation and Synthesis of Key Findings

The study's findings paint a nuanced picture of mobile network QoS in Kenya between 2015 and 2017, highlighting significant advancements alongside persistent challenges from the consumer's viewpoint. The mixed-methods approach proved invaluable in providing both the scale and the depth required to understand this complex landscape. The quantitative data established the prevalence and magnitude of perceived QoS issues across a large sample, identified statistical differences between operators and locations, and quantified the relative importance of various QoS dimensions on overall satisfaction. The qualitative data provided the crucial human element, offering rich narratives and context that explained the practical impact of these issues on users' daily lives and elaborated on their experiences and frustrations.

One of the most striking and consistent findings across both quantitative and qualitative data is the pronounced *urban-rural digital divide* in perceived QoS. Quantitative analysis showed significantly lower average perceived coverage, data speeds, and network reliability in rural areas compared to urban centers (as illustrated in the tables in Section 10.1). This empirical evidence of disparity was powerfully echoed in qualitative interviews and FGDs, where rural participants described fundamental struggles to find a signal for basic voice calls and reported near-total absence of reliable data connectivity (Theme 1, Case 3). This convergence underscores that while MNOs, particularly Safaricom, had achieved considerable national coverage by 2017 (as indicated by CA reports and operator data), the quality and technological depth of that coverage varied drastically, effectively excluding a significant portion of the rural population from the benefits of mobile broadband that urban users were increasingly accessing. This finding aligns with broader literature on the digital divide in developing economies, where infrastructure rollout is often prioritized in economically viable urban areas, leaving rural regions underserved (Mutongume, et al., 2018; Kuria & Makau, 2016).

The study also revealed that *network reliability* and *data speed* were the most critical technical determinants of overall consumer satisfaction during this period. The quantitative regression analysis (Section 10.1) clearly identified perceived network reliability and perceived data speed as the strongest positive predictors of satisfaction. This quantitative result is profoundly illuminated by the qualitative data. Themes related to frustrations with data speed (Theme 2) and the critical impact of reliability issues (Theme 3) provide the 'why'. Users described the tangible frustrations of slow data preventing effective use of smartphones for browsing, social media, and streaming (Case 2). More significantly, the qualitative data highlighted the paramount importance of reliability for **mobile money transactions**, particularly M-Pesa (Theme 7, Case 1). For many Kenyans, mobile money was an essential financial tool, and any network unreliability directly impacted their livelihoods and financial security. This specific context of high mobile money reliance in Kenya during 2015-2017 adds a critical dimension to the understanding of 'reliability' beyond simple dropped calls; it means reliable access to essential financial services. This finding resonates with IS Success models (DeLone & McLean, 2003), where system quality (reliability, speed) is shown to influence user satisfaction and perceived benefits (economic activity via mobile money).

The comparative analysis among major operators provided quantitative evidence of a clear hierarchy in consumer-perceived QoS, with Safaricom consistently ranking highest across key metrics (coverage, speed, reliability, satisfaction), followed by Airtel Kenya, and then Telkom Kenya (Orange). This quantitative ranking (Section 10.1) is directly supported by qualitative narratives (Theme 6) where users articulated their reasons for preferring Safaricom (perceived wider coverage, M-Pesa reliability) or choosing Airtel (competitive pricing, perceived good speed in certain areas) while noting the limitations of Telkom's network during this timeframe. This perceived performance hierarchy among operators reflected their differential investments in network infrastructure, particularly the rollout of 3G and 4G technologies, and their established market positions during the 2015-2017 period (as discussed in Section 3 and evidenced by CA data). Safaricom's early and broader investment in 4G and its extensive 3G network gave it a perceived edge in data speed and coverage, while its dominant position and the ubiquity of M-Pesa solidified its perception of reliability for essential services. The findings align with competition analysis literature suggesting that market structure influences service quality outcomes, though in this case, dominance by one player seemed to correlate with higher perceived quality for its subscribers, likely due to resource advantages for investment.

Beyond technical parameters, the study confirmed the importance of *non-technical factors* like customer service quality and perceived value for money in shaping overall satisfaction. Quantitative analysis identified these as significant predictors (Section

10.1). Qualitative data provided specific instances of frustration with customer care responsiveness, issue resolution, and perceived lack of transparency regarding billing and data usage (Theme 4, 5, Case 4). Users felt that technical issues were exacerbated by poor support, and questions about data depletion eroded trust and the perception of value for money. This aligns with adapted SERVQUAL models (Munylwel, et al., 2015; Oyeniyi & Abiodun, 2012) which emphasize customer care and transparency alongside technical reliability and responsiveness in determining service quality perceptions. The qualitative finding that value for money was assessed based on the *experienced quality* relative to cost (Theme 5) highlights that competitive pricing alone was insufficient; it had to be matched by reliable performance to generate satisfaction and trust.

Finally, the interplay between user *expectations and experienced reality* (Theme 8) emerged as a crucial element in shaping perceived QoS, consistent with Expectation-Confirmation Theory (ECT/ECM). The rapid advancement in mobile technology and associated marketing efforts during 2015-2017 often set high expectations for speed and seamless connectivity. When the reality of network limitations, congestion, or inconsistent coverage fell short, it led to dissatisfaction, particularly among users who had upgraded to smartphones and expected to fully utilize data-intensive applications (Case 2). This emphasizes that managing customer expectations through realistic communication is as important as continuous network improvement.

In synthesis, the study's findings from 2015-2017 reveal a mobile QoS landscape characterized by significant geographical and operator-based disparities. While technological progress was evident, particularly in urban areas and for the market leader, the rapid surge in data demand, coupled with uneven infrastructure rollout, meant that many consumers, especially in rural regions or using networks with less capacity, experienced frustrating limitations in coverage, speed, and reliability. Crucially, for a large segment of the population reliant on mobile money, network reliability was not merely a matter of convenience but had direct economic consequences. Consumer satisfaction was a product of this complex interaction between technical performance, non-technical service delivery, and the gap between expectations and real-world experience.

Contextualization within Existing Literature

The findings of this study align with and contribute to the broader literature on mobile network Quality of Service and Quality of Experience, particularly in developing country contexts. The clear identification of the urban-rural divide in QoS aligns with studies in other African countries (Adanu & Olabode, 2016; Mutongume, et al., 2018) and global south regions, consistently showing that geographical location dictates access to reliable and high-speed mobile broadband due to disparities in infrastructure investment. The study provides specific empirical evidence of this phenomenon within Kenya during a critical period of transition (2015-2017), detailing not just coverage gaps but also disparities in perceived speed and reliability, thereby expanding on earlier literature that might have focused primarily on voice QoS or basic connectivity.

The emphasis on network reliability and data speed as key drivers of consumer satisfaction also resonates strongly with the literature on mobile broadband QoS and QoE (Balaji, et al., 2013; Mosleh, et al., 2016). As data usage surged globally, user focus shifted from basic voice quality to the performance of internet-dependent applications. The study confirms that by 2015-2017 in Kenya, perceived data performance was central to the user experience, reflecting a maturation of the mobile market beyond voice and SMS dependency. The findings that reliability is a slightly stronger predictor of satisfaction than speed could be attributed to the fundamental need for a stable connection for crucial tasks, particularly mobile money, even more so than achieving the highest speeds, a point that may be more pronounced in contexts with high mobile money adoption compared to some studies focused purely on entertainment or information access.

The study's contribution is particularly significant in its specific focus on the ****critical role of mobile money reliability**** in shaping QoS perceptions and overall satisfaction in the Kenyan context. While literature acknowledges the importance of essential services (DeLone & McLean, 2003), the level of reliance on mobile money in Kenya and the direct economic impact of network unreliability on daily life (as evidenced in qualitative findings and Case 1) provides a compelling, context-specific illustration of how QoS failures in one service layer (underlying network) can severely impact the utility and trust in a critical application layer (mobile money). This reinforces the need for QoS frameworks in such markets to explicitly consider the reliability requirements of widely adopted, economically vital applications.

The finding that non-technical factors like customer service and transparency significantly influence satisfaction also aligns with broader service quality literature (Parasuraman, et al., 1988) and studies on mobile service satisfaction in Africa (Munylwel, et al., 2015; Oyeniyi & Abiodun, 2012). The qualitative insights add depth by detailing the specific frustrations encountered by users (Theme 4, Case 4), such as unhelpful agents and unclear billing, suggesting that improvements in these areas offer a pathway to enhance overall user experience even while technical network upgrades are ongoing.

By employing a mixed-methods approach, the study successfully addresses the literature gap concerning the discrepancy between objective technical QoS metrics and subjective consumer perception (Gorcun, et al., 2015; Khan, et al., 2017). While this study did not conduct its own real-time technical measurements, it utilized objective CA data for contextual comparison and directly captured subjective perceptions from a large sample. The findings demonstrate that while regulatory data trends generally align with perceived performance (e.g., Safaricom's higher ranking in both), the consumer experience is shaped by the nuances of reliability under load, the impact on specific applications (like mobile money), and non-technical factors – elements not fully captured by

aggregate technical compliance reports. The qualitative data, in particular, bridges this gap by explaining **why** users perceived quality in a certain way based on their real-world usage scenarios and frustrations.

Overall, the study validates key trends observed in the global and regional literature on mobile QoS, such as the urban-rural divide and the growing importance of data performance. However, it significantly contributes by providing specific, mixed-methods empirical evidence from Kenya during the critical 2015-2017 period, offering unique insights into the high-stakes consumer demand for reliability driven by mobile money adoption and the complex interplay of technical and non-technical factors shaping satisfaction in this specific context.

Methodological Considerations

The study's mixed-methods design, combining quantitative surveys with qualitative interviews and focus groups, is a significant strength, enabling a comprehensive understanding of mobile QoS from the consumer perspective. The quantitative component provided generalizable data on perceptions and satisfaction across a large sample, allowing for statistical comparison across operators and locations. The qualitative component offered rich, in-depth insights into the 'why' behind these numbers and the lived experiences of users, which are crucial for understanding subjective QoS (Adanu & Olabode, 2016). The integration of findings from both methods strengthened the conclusions through triangulation and complementarity.

However, the study is subject to several limitations that should be acknowledged:

Timeframe Specificity: The data was collected between 2015 and 2017. The mobile network landscape in Kenya is dynamic, with ongoing technological advancements (e.g., further 4G expansion, early 5G discussions), changes in market share, and evolving consumer behaviors. The findings reflect the QoS situation during that specific period and may not fully represent the current state of affairs. This is an inherent limitation of any historical study but defines the scope and relevance of the research.

Reliance on Perceived QoS: The study's focus is explicitly on the consumer dimension, relying on users' subjective perceptions of QoS parameters rather than objective network measurements conducted by the researchers. While this aligns with the study's objective of understanding user experience, perceived quality can be influenced by factors beyond the network itself, such as the user's device, personal expectations, technical literacy, and temporary local interference (Gorcun, et al., 2015). Although regulatory data was used for contextual comparison, a direct, real-time correlation between measured technical performance and individual user perception was not undertaken.

Recall Bias: Participants were asked to reflect on their experiences during the 2015-2017 period. There is a possibility of recall bias, where participants' memories or perceptions might be influenced by more recent experiences outside the study timeframe, leading to inaccuracies in reporting past events or feelings.

Sampling Limitations: While a multi-stage sampling strategy aimed for diversity, practical constraints in accessing certain remote areas or specific demographic groups during the field research (2015-2017) might have limited the absolute representativeness of the sample. Reliance on self-reported primary operator might not account for users frequently switching SIM cards or using multiple operators simultaneously, though efforts were made to capture primary usage.

Qualitative Sample Size and Generalizability: The qualitative sample, while purposively selected for depth and diversity, is small compared to the quantitative sample. Findings from qualitative data are not statistically generalizable to the entire population but provide detailed insights and context that complement the quantitative results.

Potential for Bias:

Response Bias: Participants might have felt inclined to give socially desirable answers or exaggerate positive or negative experiences.

Interviewer Bias: Although enumerators and researchers were trained, their interactions could unintentionally influence participant responses.

Selection Bias: While striving for randomness in the quantitative survey, selection within public spaces might inadvertently exclude certain groups (e.g., those less mobile, those at home). Purposive sampling for qualitative components is intentional but inherently non-random.

Despite these limitations, the study's rigorous data collection protocols (during 2015-2017), systematic analysis, and the triangulatory power of the mixed-methods design enhance the credibility and relevance of the findings for understanding consumer QoS in Kenya during the specified period. The limitations highlight the inherent challenges of conducting large-scale, perception-based field research and provide context for interpreting the results.

Implications for Stakeholders

The findings of this study have significant implications for mobile network operators, policymakers, and regulators in Kenya.

Implications for Mobile Network Operators

The study provides MNOs with empirical evidence from 2015-2017 regarding what truly mattered to their customers in terms of service quality.

Prioritize Reliability and Consistent Data Speed: The quantitative finding that reliability and data speed were the strongest predictors of satisfaction should guide network investment strategies. Operators should focus not only on expanding coverage or achieving theoretical peak speeds but ensuring consistent, stable connections and reliable performance, particularly during peak hours and in congested areas. Addressing network congestion in urban centers and improving connection stability in rural areas are critical for enhancing the experienced QoS.

Address the Urban-Rural Divide: The stark disparity in perceived QoS highlights the need for targeted investment in rural infrastructure. Expanding 3G/4G coverage and capacity in rural areas is essential to provide equitable access to mobile broadband and enable rural populations to participate fully in the digital economy. This requires overcoming economic challenges in deploying infrastructure in less densely populated regions.

Enhance Customer Service and Transparency: Frustrations with customer care and transparency significantly impact satisfaction. Operators should invest in improving the responsiveness and effectiveness of their customer support channels, ensuring agents are equipped to resolve technical issues related to network performance. Clear and transparent communication regarding data usage, billing, and service limitations is crucial for building trust and managing customer expectations (Theme 4, 5, 8).

Recognize the Criticality of Mobile Money Reliability: Given the central role of mobile money, particularly M-Pesa, in daily life, MNOs must treat the reliability of the underlying network for financial transactions as a paramount QoS requirement. Any instability impacting mobile money services has severe repercussions for users and significantly damages perceived quality and trust (Theme 7, Case 1). Ensuring resilience and stability for mobile money access should be a top network design and monitoring priority.

Align Marketing with Reality: The gap between expectations and experienced reality suggests that marketing communications should be more realistic about achievable speeds and coverage limitations in different areas. Managing customer expectations effectively can reduce dissatisfaction stemming from unmet promises (Theme 8).

Implications for Policymakers and Regulatory Bodies (Communications Authority of Kenya - CA)

The study's findings offer valuable insights for the CA in its role of monitoring and regulating QoS and promoting consumer interests.

Evolve QoS Monitoring Metrics: Regulatory monitoring should consider evolving beyond basic technical compliance metrics measured in specific conditions (e.g., drive tests) to incorporate aspects of consumer experience, such as perceived reliability during peak hours, application-specific performance (e.g., speed adequacy for video), and the reliability of critical services like mobile money. Crowdsourced data from users, if validated and properly utilized, could complement traditional measurement methods (Khan, et al., 2017).

Strengthen Enforcement on Key Parameters: Regulatory enforcement actions should prioritize issues directly impacting consumer satisfaction, particularly consistent network reliability and data speeds, alongside fundamental coverage requirements. Penalties or incentives could be tied more closely to performance as experienced by a representative sample of users in real-world conditions.

Address the Rural Digital Divide Through Policy: The empirical evidence of the urban-rural divide necessitates policy interventions to incentivize MNO investment in underserved rural areas. Strengthening the Universal Service Fund (USF) mechanisms and ensuring effective deployment of allocated funds for rural connectivity projects are crucial steps to promote equitable access to quality mobile services. Policies could mandate minimum performance standards (speed, reliability) for all licensed areas, not just national averages.

Enhance Consumer Protection: The issues related to customer service and transparency highlight the need for stronger consumer protection regulations. This includes mandating clear information on tariffs, data usage, service limitations, and effective, accessible mechanisms for handling consumer complaints and ensuring timely resolution, particularly concerning billing disputes or service outages (Munylwel, et al., 2015).

Promote Transparency and Information Dissemination: The regulator can play a role in improving transparency by publishing accessible, consumer-friendly reports on operator performance, including perceived quality aspects where feasible. Educating consumers about their rights regarding service quality and avenues for redress is also important.

By addressing the specific QoS challenges and consumer perceptions highlighted in this study from 2015-2017, both operators and policymakers can work towards a mobile telecommunications ecosystem in Kenya that is not only technically advanced but also consistently reliable, equitable, and aligned with the actual needs and expectations of its diverse consumer base. The findings provide an evidence-based foundation for strategic decisions aimed at enhancing mobile network quality and fostering continued digital inclusion and economic participation in the country.

V. Conclusions

This study has thoroughly examined the Quality-of-Service (QoS) parameters of Kenyan mobile networks between 2015 and 2017 from the consumer perspective, providing a robust understanding of mobile network performance and user experience during a pivotal period of technological transition and rapid data adoption. The integration of quantitative survey data with qualitative narratives has produced a nuanced and empirically grounded assessment, bridging gaps between technical network measurements and real-world consumer perceptions across diverse geographies and demographics within Kenya.

VI. Summary of Key Findings

The research revealed distinct disparities in perceived QoS across geographic regions, operators, and service dimensions. Foremost among the findings is the pronounced urban-rural digital divide: consumers in urban and semi-urban locations generally reported significantly better network coverage, faster data speeds, and higher reliability compared to rural users, who often faced substantial service limitations and connectivity challenges. This divide reflects ongoing infrastructure investment priorities and economic realities, leaving rural populations with predominantly 2G or limited 3G capabilities, thus hampering their participation in the growing digital ecosystem.

Regarding operator performance, Safaricom emerged as the most positively perceived provider in terms of coverage, data speed, network reliability, and overall user satisfaction, consistent with its dominant market share and substantial investment in network expansion, including early 4G rollout. Airtel Kenya occupied the intermediate position, offering competitive pricing and reasonable performance in urban areas but with more limited geographic reach and coverage quality relative to Safaricom. Telkom Kenya (including its Orange Kenya phase) consistently ranked lowest on consumer-perceived QoS parameters, constrained by a smaller infrastructure footprint and delayed technological upgrades.

The study also identified network reliability—especially the consistent availability of stable connections for both voice and data services—as the strongest driver of overall consumer satisfaction. Data speed ranked as the second most influential factor, reflecting the rapid rise in smartphone penetration and mobile internet usage during the study period. Crucially, reliability for mobile money services, particularly M-Pesa, was underscored as an indispensable aspect of QoS by many users, given the centrality of mobile financial transactions to everyday economic activity and social welfare in Kenya.

Beyond technical factors, non-technical dimensions such as customer service quality, transparency in billing and data usage, and perceived value for money also significantly shaped consumer satisfaction. Frustrations arising from unresponsive or ineffective customer care and unclear communication were common and often amplified negative perceptions of network quality.

Qualitative insights elucidated the lived realities behind these findings: rural users' struggles to find reliable signal coverage, urban users' frustration with inconsistent data speeds and buffering during peak hours, the anxiety caused by mobile money transaction failures, and the compounded dissatisfaction stemming from poor customer support. These narratives illustrated that QoS is not merely a technical or commercial endeavor but deeply impacts social connectivity, economic participation, and trust in service providers.

Significance and Contributions of the Study

This study contributes to the telecommunications research literature by providing an in-depth, mixed-methods analysis capturing the consumer dimension of mobile network QoS in a rapidly evolving developing market context. Its focus on the 2015-2017 timeframe captures a critical transition marked by burgeoning data consumption, emergent 4G deployment, and intensifying competition among Kenyan mobile operators.

By systematically correlating consumer perceptions with coverage and performance disparities across operators and regions, the study fills empirical gaps left by prior research focused predominantly on technical network metrics or regulatory reports. Highlighting the paramount importance of mobile money reliability contextualizes QoS in Kenya's unique digital ecosystem, where mobile financial services underpin large segments of the economy. Furthermore, the incorporation of user expectations and subjective experiences advances the understanding of the qualitative dimensions of QoS, demonstrating the limitations of solely objective measurements for gauging consumer satisfaction.

The study also provides nuanced insights into the challenges faced by smaller operators and underserved populations, offering an evidence base to inform policy and industry decisions aimed at fostering equitable service quality and digital inclusion. Through its comprehensive approach, the research bridges traditional technical QoS frameworks with service quality, information systems, and expectation-confirmation theories to produce a holistic model of mobile network quality from the consumer viewpoint.

Practical Applications and Implications

The findings hold significant practical value for multiple stakeholders in Kenya's telecommunications sector. For mobile network operators, understanding that network reliability and data speed are primary drivers of consumer satisfaction underscores the need to prioritize infrastructure investments and operational strategies that reduce congestion, improve coverage depth—especially in rural and semi-urban areas—and enhance network stability to support critical applications like mobile money. Furthermore, the

importance of customer service responsiveness and transparency highlights opportunities for operators to improve consumer trust and loyalty beyond technical metrics, by addressing pain points in complaint resolution and billing clarity.

For policymakers and regulators, the documented urban-rural disparities emphasize the necessity for policies that incentivize rural network deployment and capacity upgrades, ensuring a more equitable digital landscape. The integration of consumer perception data alongside technical QoS assessment suggests that regulatory frameworks should increasingly incorporate consumer feedback, application-specific performance standards (e.g., for mobile money services), and real-world usage conditions. Strengthening consumer protection mechanisms and promoting clear operator communication about service capabilities and limitations are also crucial to managing user expectations and enhancing satisfaction.

These insights can shape future investment priorities, regulatory policies, and consumer education efforts to enhance the overall quality and inclusiveness of mobile telecommunications services in Kenya.

Areas for Future Research

While this study provides a comprehensive snapshot for the 2015-2017 period, mobile telecommunications in Kenya are evolving rapidly, presenting diverse avenues for future inquiry:

Longitudinal Studies: Follow-up studies tracking QoS consumer perceptions over subsequent years (post-2017) would illuminate the impact of continued 4G expansion, emerging 5G technologies, and shifting usage patterns, allowing for dynamic assessment of QoS improvements and persistent challenges.

Objective-Subjective Correlation Studies: Further research integrating real-time technical network measurements captured via crowdsourcing or directly from operator data with concurrent subjective consumer feedback can more precisely map the relationship between objective performance and perceived quality.

Application-Specific QoS Evaluation: Given the growing diversity of mobile applications, focused studies examining QoS impacts on particular services like mobile money, e-health, e-learning, and entertainment platforms would provide actionable insights for tailored network and service improvements.

Deep-Dive into Rural QoS Challenges: Targeted qualitative and quantitative research to understand the infrastructural, economic, and social barriers limiting rural QoS improvements and exploring sustainable models for rural network extension and operation.

Consumer Behavior and Switching Dynamics: Studies exploring how perceived QoS influences consumer behavior regarding operator switching, multi-SIM usage, and willingness to pay for premium services would help operators refine marketing and service strategies.

Impact of Non-Technical Factors: Further examination of how customer service innovations, transparency initiatives, and enhanced consumer education affect satisfaction and loyalty in the Kenyan telecommunications market.

These research directions would deepen the understanding of the complex socio-technical ecosystem of mobile networks in Kenya and inform strategies for achieving high-quality, equitable, and consumer-centered telecommunications services in the future.

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