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A Roadmap for the Future of Digital Terrestrial Broadcasting in Zambia

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Abstract:- This study analyzed challenges facing digital terrestrial broadcasting (DTB) in Zambia, including declining subscriptions and threatened spectrum availability. The three key objectives were(1) To Identify innovative business models that would reverse declining DTB subscription levels and ensure a sustainable return on investment.; (2) To Assess and recommend new technologies that DTB networks can leverage on to enhance service delivery; (3) To Evaluate and recommend regulatory measures to ensure sufficient spectrum is available for DTB. The study employs a mixed method approach. The data collection was done using random sampling for the collection of quantitative data subscribers' preferences for DTB subscriptions verses Online Streaming (Over-The-Top) Services, as well as reasons for choosing one service over the other. The qualitative data was collected from Targeted sampling was used to select participants based on their knowledge and experience in broadcasting technology. These were TOPSTAR and Go TV, which are authorized public and private DTB Network Operators, respectively; The Independent Broadcasting Authority(IBA) and The Zambia Information and Communications Authority (ZICTA), which are organization that regulate the industry. The survey found that online streaming was the most preferred service compared to DTB. Respondents cited higher video quality, variety of content and on-demand availability as reasons for choosing online streaming services. The study concludes that proactive innovation through new technologies, business models and partnerships is essential for DTB to thrive amidst digital disruption. Regulators also need gradual, flexible approaches allowing broadcasters time to adapt to inevitable mobile-driven spectrum reallocations. The key recommendations are: (1) Develop clear regulatory roadmaps enabling digital evolution of DTB networks; (2) Support collaborative relationships between telecom and broadcast operators to accelerate new technologies; (3) Build empirical evidence through audience research and industry pilot studies to guide policies; (4) Empower citizens and broadcasters through digital literacy and local content development; (5) Assist public service broadcasters managing competitive pressures through targeted universal service policies. With visionary leadership and collaboration, Zambia's broadcast industry can retain vital societal roles while embracing new opportunities. This study provides strategies to guide stakeholders in securing DTB's future sustainability and competitiveness.

Keywords:- *Digital Terrestrial Broadcasting, Subscription, Spectrum, Online Streaming.*

I. INTRODUCTION

A. Background:

Many Digital Terrestrial Broadcasting (DTB) has been an integral broadcasting technology in Zambia for over a decade, providing news, entertainment, and information access to millions of citizens. However, the exponential growth of online video streaming globally poses a disruptive challenge to traditional broadcasters (Lombardo, 2017). Zambian DTT operators face declining subscription revenues as audiences shift to over-the-top (OTT) services like Netflix (Bwalya & Mutale, 2022).

DTT also relies exclusively on the ultra-high frequency (UHF) band from 470-694 MHz - spectrum threatened by reallocation pressure to accommodate growing mobile data demand (Jesenko& Womersley, 2022). DTB broadcasts were squeezed into this range after clearance of the 700 and 800 MHz bands for mobile broadband (Gulyaev, 2017). This remaining sub-700 MHz spectrum has propagation advantages for wide coverage.

To remain viable amid these headwinds, Zambian DTB operators require new strategies and innovations. This study aimed to develop a roadmap of solutions spanning business models, technologies, and policy to secure DTB's future. Surveys, interviews, literature review, and technical analysis illuminated pathways for broadcasters to adapt and evolve.

Zambia undertook DTB migration from 2014-2017, converting analog transmitters nationwide to digital (GRZ, 2014). This improved spectrum efficiency and enabled more channels and better quality. State broadcaster ZNBC and Star Times formed a joint venture, TopStar Communications, to operate the DTT network as a public signal distributor (MIBS, 2017).

However, TopStar has struggled to turn a profit and repay government digital migration loans due to low subscription uptake (ZICTA, 2021). Online streaming platforms like Showmax are gaining viewers, while DTB subscriptions languish around 11-15% of TV households (Macauhub, 2019).

Globally, the sub-700 MHz band faces potential mobile reallocation, as seen at past ITU World Radio communication Conferences (WRCs) like WRC-12 and WRC-15 (ATU, 2022). Studies are underway on sharing/compatibility between broadcast and mobile services in the 470-694 MHz band for consideration at WRC-23. This could further squeeze DTT spectrum.

Facing these headwinds, DTT operators need fresh models to remain viable and competitive. This study aimed to illuminate solutions.

B. Statement of the Problem:

Several studies have been conducted in Zambia and around the world on Digital Terrestrial Broadcasting (DTB) delivery, focusing on different aspects of it. In Zambia, scholars such as Ilinga (2017) and Bwalya and Nkunda (2022) have postulated that media technologies shape how individuals in society think, feel, act, and how a society operates as it moves from one technological age to another. DTB broadcasting in Zambia is facing a challenge of declining subscription levels due to the rising popularity of online video on demand (VoD) and video streaming preferences over traditional TV, as well as the imminent threat of further reduced radio frequency spectrum availability for DTB at the international level. In addition, Chisumbe (2020) found that 89.79% of the total UHF band channels in Zambia are unused, leaving room for the deployment of two-way data communications networks using these frequencies. Therefore, there is a need to carefully consider the challenges facing DTB in Zambia and develop a coordinated response.

C. Research Aim:

This research aims to develop a roadmap that can be used in the near future to enhance the quality of service delivery of Digital Terrestrial Broadcasting (DTB) networks by evolving with emerging technological advancements in order to mitigate threats that could render the networks obsolete.

D. Specific Objectives:

- To Identify innovative business models that would reverse declining DTB subscription levels and ensure a sustainable return on investment.;
- To Assess and recommend new technologies that DTB networks can leverage on to enhance service delivery;
- To Evaluate and recommend regulatory measures to ensure sufficient spectrum is available for DTB.

E. Research Questions:

- What innovative business models can be explored to effectively reverse the declining subscription levels of DTB and ensure a sustainable return on investment?
- How can DTB networks leverage on emerging technologies to enhance service delivery and stay competitive in the evolving media landscape?
- What are the regulatory measures that can be considered to ensure the availability of sufficient spectrum for DTB networks, contributing to their operational efficiency and quality of service?

II. MATERIALS AND METHODS

A. Introduction:

The research design, the study region, the study population, the study sample characteristics, the sampling methodologies and the data collection and analysis methods that were employed will all be covered in detail in this chapter.

B. Research Strategy:

This study employed a mixed-methods strategy that combined qualitative and quantitative techniques. The mixed method approach was used in order to triangulate the information that was collected.

C. Study Area:

The study was carried out in urban areas of Zambia, with a particular focus on Lusaka Province. Data collection targeted respondents in the capital city Lusaka as well as other major urban centers around the country. This urban focus enabled assessing consumer perspectives on digital broadcasting among Zambia's more technologically connected and media-savvy populations. Urban residents, especially in Lusaka, generally have higher digital literacy, Internet penetration and exposure to emerging viewing technologies compared to rural populations.

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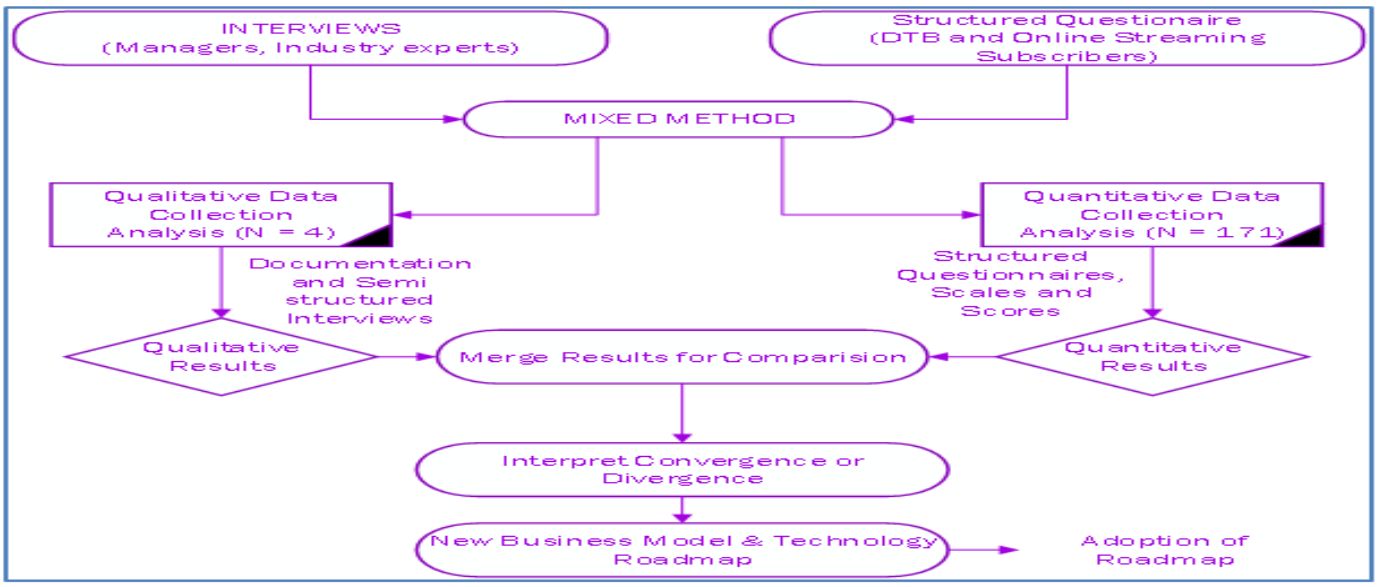

Fig. 1: Research Strategy
Source: Author

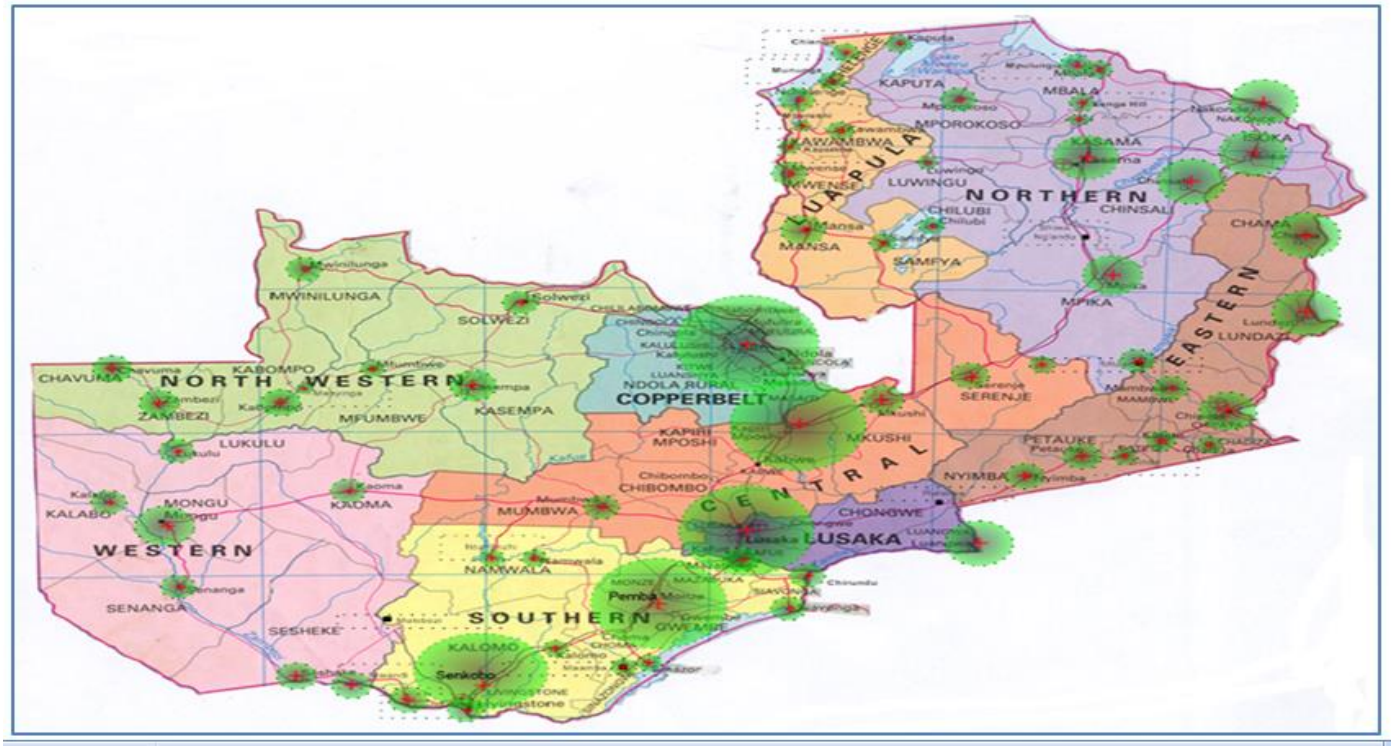

Fig. 2: Digital Terrestrial Broadcasting Coverage Areas
Source: Topstar

D. Study Population:

The study population concentrated on urban areas, and this provided insights into the factors driving the uptake and preferences for online streaming and digital terrestrial broadcasting services among early adopter groups. The experiences and attitudes of urban audiences in Zambia provides leading indicators for likely future trends in broadcasting viewership as services diffuse to wider segments of the population over time. The targeted urban focus thereby offered a strategic vantage point to examine evolving viewer behaviors and competitive challenges for traditional broadcast media platforms.

E. Study Sample:

A total sample of 171 respondents was surveyed for the study. This sample size was determined using Slovin's formula to provide 95% confidence level with a 5% margin of error. The target population comprised urban residents in Lusaka and other major cities of Zambia. The sample ultimately comprised 49% men and 22% women, with 79% having tertiary education or higher. In terms of age, the mean was 40 years and median 38 years. The sample reflected a high degree of technological literacy, with 48% subscribed to online streaming platforms and 41% using digital terrestrial broadcasting. The high response rate of

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74% added credibility to the results. While not fully representative of the national population, the urban-concentrated sample provided important insights into evolving viewing behaviors and technology preferences among early adopter consumer segments, which can signal future trends as services diffuse more widely. The sample size and selection enabled identifying key drivers and challenges impacting digital broadcasting adoption.

F. Sampling Techniques:

A stratified random sampling technique was used to achieve diversity across key demographics like age, gender and education levels.

G. Data Collection Instruments:

171 respondents who made up the sample population were interviewed using a semi-structured questionnaire together data for objective one. The questionnaire primarily focused on the demographic and subscriber trends as well as the sample population's knowledge on DTB and Online Streaming service delivery.

Qualitative data was obtained using key informant interview guides to get information from Topstar and GOTV as the DTB signal distributer and Private Signal distributer respectively. More qualitative data was obtained from the Independent broadcasting Authority(IBA)and Zambia Information and Communications Technology Authority (ZICTA) because of their mandates as Regulators of broadcasting and Telecom industries in Zambia. One official from each institution was be interviewed. The qualitative data was obtained to answer objectives two and three, however, information from the online questionnaire was also used to supplement the qualitative data obtained.

H. Data Analysis:

The researcher used Kobo Tool Box Software as well as Microsoft Excel to analyse the quantitative data. The qualitative data was analysed using Microsoft excel. Objective one was analyzed using descriptive analysis. The mode was determined to show the highest result. Tables and graphs were generated to show the results.

III. RESULTS

A. Introduction:

The outcomes of data collecting and data analysis are presented in the following sections. To provide the reader a quick overview of the sample population, the first section will present the demographics of the sample that was interviewed. The analysis of data based on the three objectives and their associated research questions will come after the demographics.

B. Demographics:

The social and economic characteristics of the sample population surveyed, are displayed in Table 1 below. 171 people were responsive to the online semi-structured questionnaire.

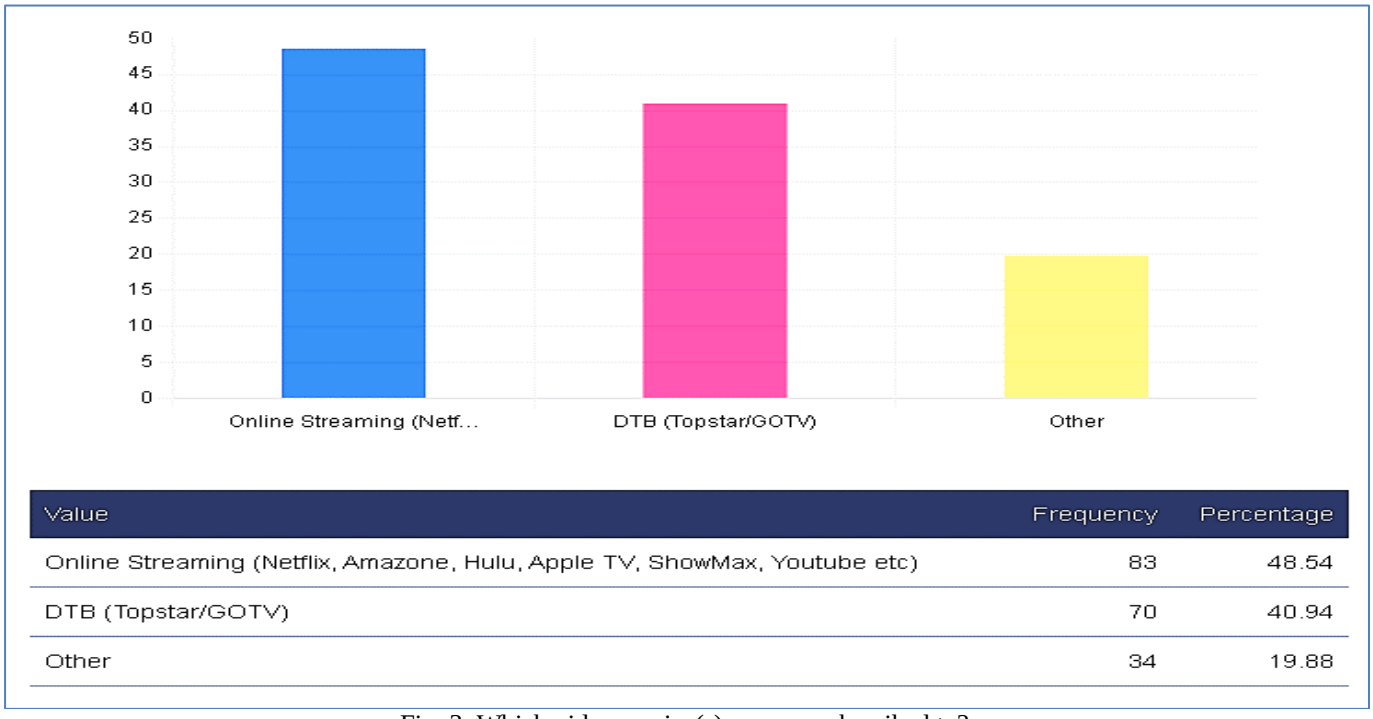
Table 1: Demographic Information of Sample Size

Variable	Count	Percent (%)
Age		
Mean	39.76	
Median	38.50	
Mode	43.00	
Standard Deviation	8.90	
Gender of respondent		
Male	85	49.7
Female	38	22.2
Education Level		
Matriculation	3	1.8
Tertiary	25	14.6
Degree	57	33.3
Postgraduate	35	20.5
Doctorate	3	1.8
Service Subscriptions		
Online Streaming	83	48.5
DTB (Topstar/GOTV)	70	40.9
Other	34	19.9
Most Preferred Service		
Online Streaming	78	45.6
DTB (Topstar/GOTV)	23	13.5
Other	20	11.7
Quality of Service		
Online Streaming	42	24.6
DTB (Topstar/GOTV)	15	8.8
Other	13	7.6
Affordability		

Online Streaming	38	22.2
DTB (Topstar/GOTV)	32	18.7
Other	10	5.9
Variety of Content		
Online Streaming	62	36.3
DTB (Topstar/GOTV)	15	8.8
Other	19	11.1
Accessibility and Available on Demand		
Online Streaming	68	39.8
DTB (Topstar/GOTV)	15	8.7
Other	12	7.0
Sample population (n)= 171		

Among the 171 participants, 49% of theparticipants were men and 22% were women and 28% did not respond to this question. The average of participants was 39, while the median was 38 and the mode was 43. The education levels of the respondents in the study varied, with the majority holding a degree (33.33%), followed by postgraduate qualifications (20.47%). Additionally, 14.62% of participants had tertiary education, while a smaller percentage had matriculation (1.75%) or doctorate (1.75%) qualifications.

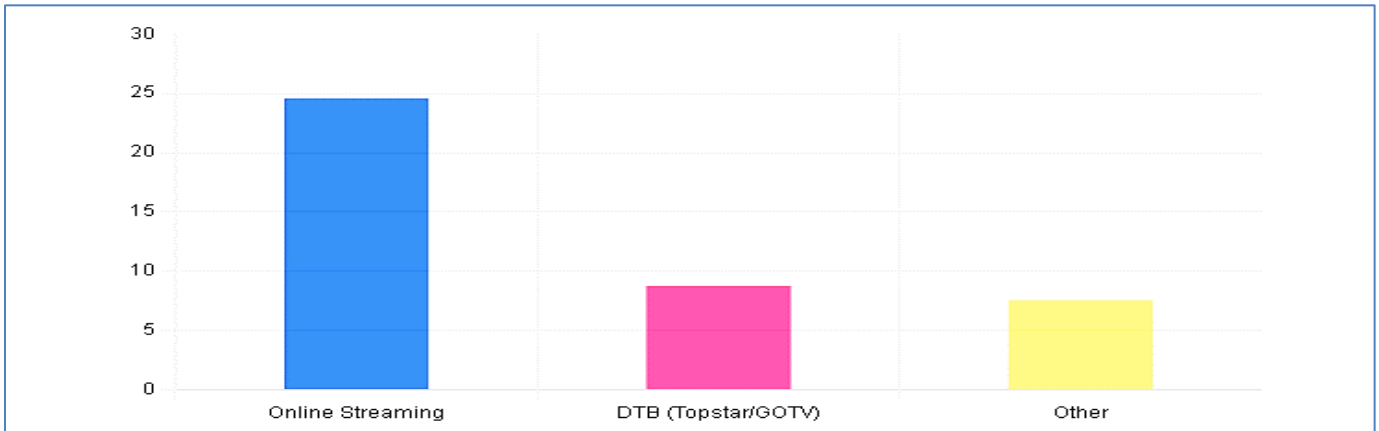
The survey revealed diverse preferences in subscription services among the respondents. A significant majority, constituting 48.54%, were subscribed to online streaming platforms such as Netflix, Amazon, Hulu, Apple TV, ShowMax, and YouTube. The second most popular choice was DTB (Topstar/GOTV), with 40.94% of respondents opting for this traditional broadcasting service. Additionally, 19.88% of participants had chosen other subscription services not specifically mentioned in the provided options. (Figure 3)



Value	Frequency	Percentage
Online Streaming (Netflix, Amazone, Hulu, Apple TV, ShowMax, Youtube etc)	83	48.54
DTB (Topstar/GOTV)	70	40.94
Other	34	19.88

Fig. 3: Which video service(s) are you subscribed to?
(123 out of 171 respondents answered this question. 48 were without data.)

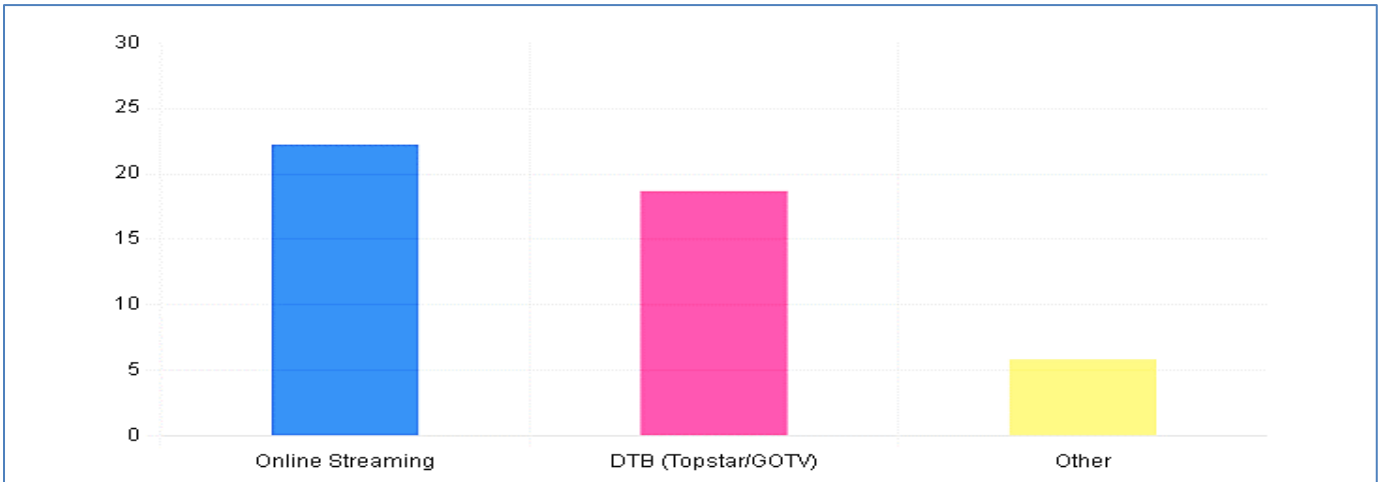
The examination of service quality preferences among respondents indicated that 24.56% favored online streaming services, 8.77% expressed a preference for DTB (Topstar/GOTV), and an additional 7.6% selected other services not specifically outlined. (Figure 4)



Value	Frequency	Percentage
Online Streaming	42	24.56
DTB (Topstar/GOTV)	15	8.77
Other	13	7.6

Fig. 4: Better Quality?
(70 out of 171 respondents answered this question. 101 were without data)

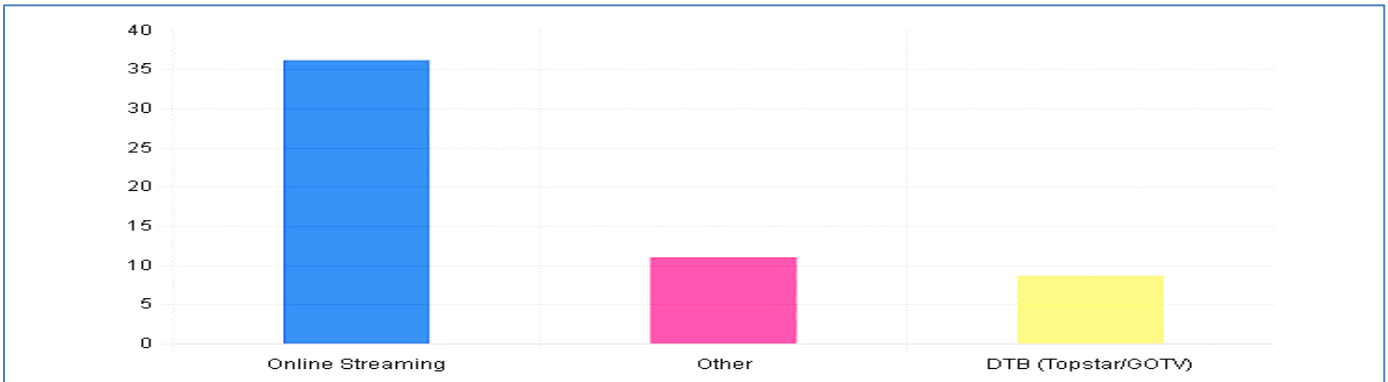
Among the surveyed respondents, online streaming services ranked as the most affordable option, with 22.22% considering it within their budget, followed by DTB (Topstar/GOTV) at 18.71%, and other services, chosen by 5.85%, perceived as the least affordable. (Figure 5)



Value	Frequency	Percentage
Online Streaming	38	22.22
DTB (Topstar/GOTV)	32	18.71
Other	10	5.85

Fig. 5: More Affordable?
(80 out of 171 respondents answered this question. 91 were without data.)

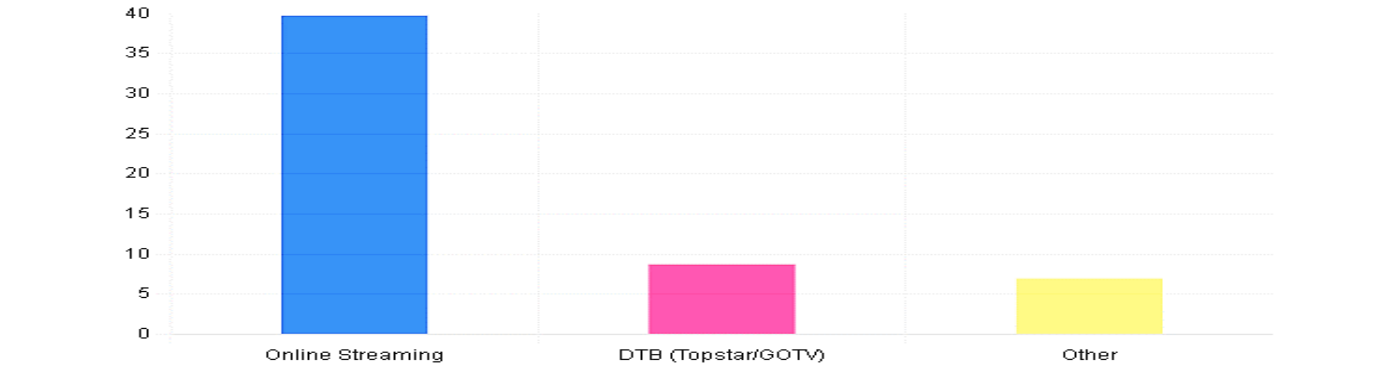
In terms of variety of content (Figure 6), respondents exhibited diverse preferences with 36.26% favoring online streaming services, 11.11% opting for other platforms, and 8.77% choosing DTB (Topstar/GOTV).



Value	Frequency	Percentage
Online Streaming	62	36.26
Other	19	11.11
DTB (Topstar/GOTV)	15	8.77

Fig. 6: More Variety of Content?
(96 out of 171 respondents answered this question. 75 were without data)

Respondents strongly emphasized accessibility and on-demand availability, with 39.77% favoring online streaming services, 8.77% opting for DTB (Topstar/GOTV), and 7.02% selecting other platforms.



Value	Frequency	Percentage
Online Streaming	68	39.77
DTB (Topstar/GOTV)	15	8.77
Other	12	7.02

Fig. 7: Accessible and Available on Demand.
(95 ut of 171 respondents answered this question.761 were without data.)

C. Analysis of Data by Objectives:

- *Specific Objective 1:* To Identify Innovative Business Models.
- *Research Question 1:* What innovative business models can be explored to effectively reverse the declining subscription levels of DTB and ensure a sustainable return on investment?

In response to the research question aimed at identifying innovative business models to reverse declining DTB subscription levels and ensure a sustainable return on investment, the survey data provides valuable insights into the preferences and priorities of the respondents. The data presented in Figure 8 highlights the key changes respondents believe DTB operators need to implement to remain competitive. The majority of participants, representing 25%, emphasized the importance of a variety of content, indicating a strong desire for diverse programming. Additionally, 22% of respondents highlighted the significance of improving the quality of service, encompassing both programs and video quality. Moreover, 15% expressed the need for reduced subscription fees, pointing towards a potential strategy for attracting and retaining subscribers. The data also indicated concerns

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regarding repeat programs (7%) and a notable interest in converging with streaming services (16%). Furthermore, a substantial 13% of respondents advocated for innovation with changes in technology. This analysis provides a breakdown of the main themes and the relative emphasis given by respondentsto meet the evolving demands of the audience and revitalize DTB subscription.

Figure 9 provides insight into perceptions on the future of DTB services compared to online streaming. An overwhelming majority of 86% think streaming will eventually replace traditional broadcast TV. This aligns with wider market trends of viewers shifting to on-demand and online entertainment options. While only 5% felt streaming would not replace DTB, the remaining 9% were uncertain. The data highlights the immense challenges facing DTB operators. Viewers are overwhelmingly expecting and embracing on-demand streaming access. To remain relevant, DTB providers must re-envision their services, harness streaming and multi-platform delivery, and focus on differentiated content and value. However, a minority are still uncertain if streaming will completely replace broadcast TV. DTB operators need to creatively make the case for the unique benefits of broadcast television while adapting their business to meet changing consumer demands. In conclusion, these findings will help inform strategies to innovatively transform DTB services for sustainability.

Table 2: Responses to what changes DTB operators can make to remain competitive

Suggested changes to DTB operators to remain competitive		
Suggestion	**Frequency**	**Percentage**
Variety of Content	17	25%
Improve Service Quality	15	22%
Reduce Subscriotion fees	10	15%
Reduce Reapeat Programs	5	7%
Converge with Streaming Services	11	16%
Innovate with Technology	9	13%

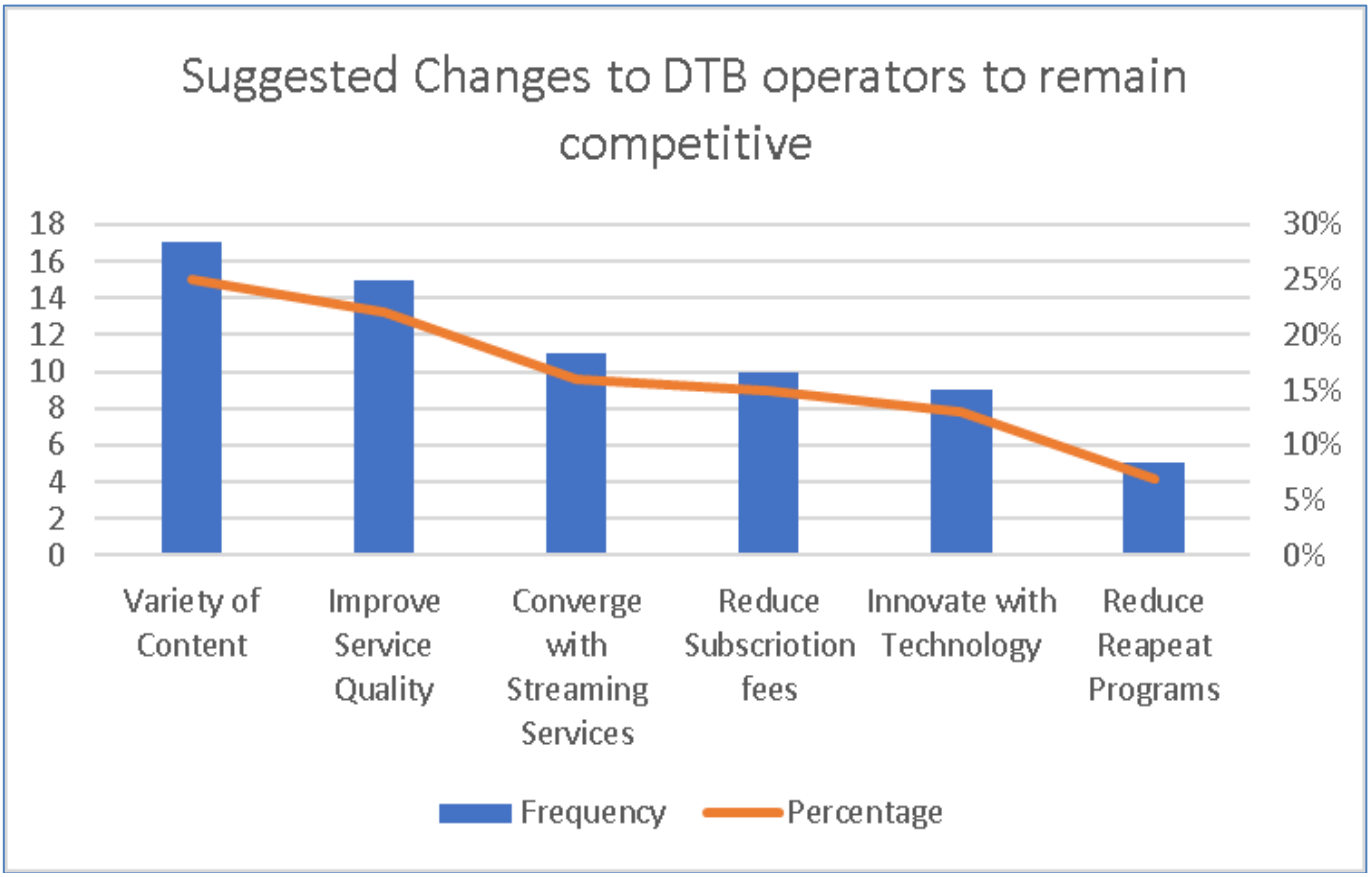
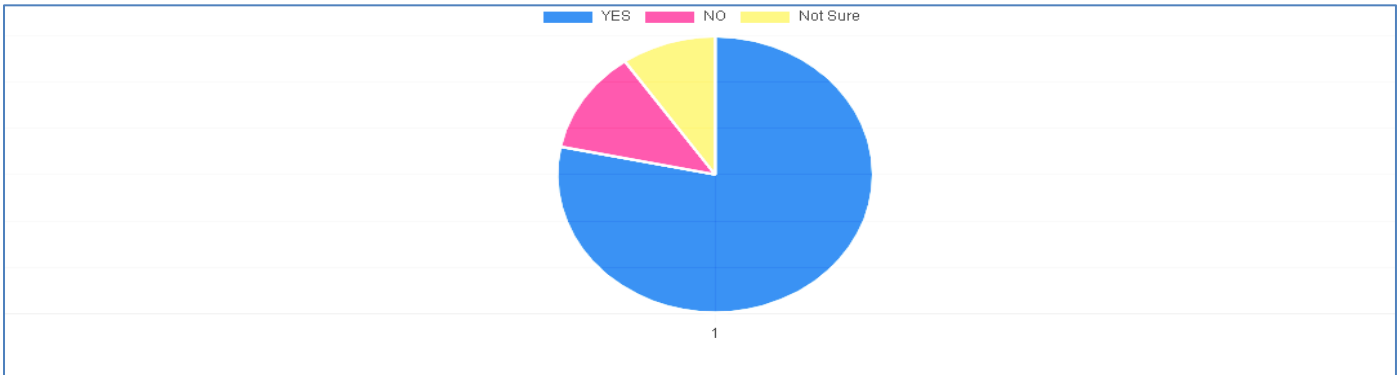


Fig. 8: What changes do you think DTB operators (Topstar/GOTV) need to make in order to remain competitive?
Source: Author



Value	Frequency	Percentage
YES	97	56.73
NO	15	8.77
Not Sure	12	7.02

Fig. 9: Do you think Online Streaming services will eventually replace traditional DTB services?
Source: Author

The survey data clearly demonstrates a strong preference for online streaming platforms over traditional broadcast television (DTB) among respondents. As illustrated in Figure 10, 46% favored streaming services while only 13% preferred DTB providers like TopStar and GOtv (Author, 2023).(121 out of 171 respondents answered this question. 50 were without data i.e. approx..30% unsure)

These findings reflect wider market trends of rapid growth in streaming and decline of broadcast television. As noted by PwC (2021), online video subscriptions grew by 26% globally in 2020 while traditional TV subscriptions fell by 3%. For example, Netflix added 36 million subscribers in 2020 reaching over 200 million members globally (PwC, 2021).

Table 3: Percentage Distribution of Respondents who Indicated which service they preferred overall

Which service do you prefer overall?		
Platform	**Frequency**	**Percent(%)**
Online Streaming	78	45.61
DTB (Topstar/GOTV)	23	13.45
Other	20	11.7
Total	**121**	**100**

Source: Author

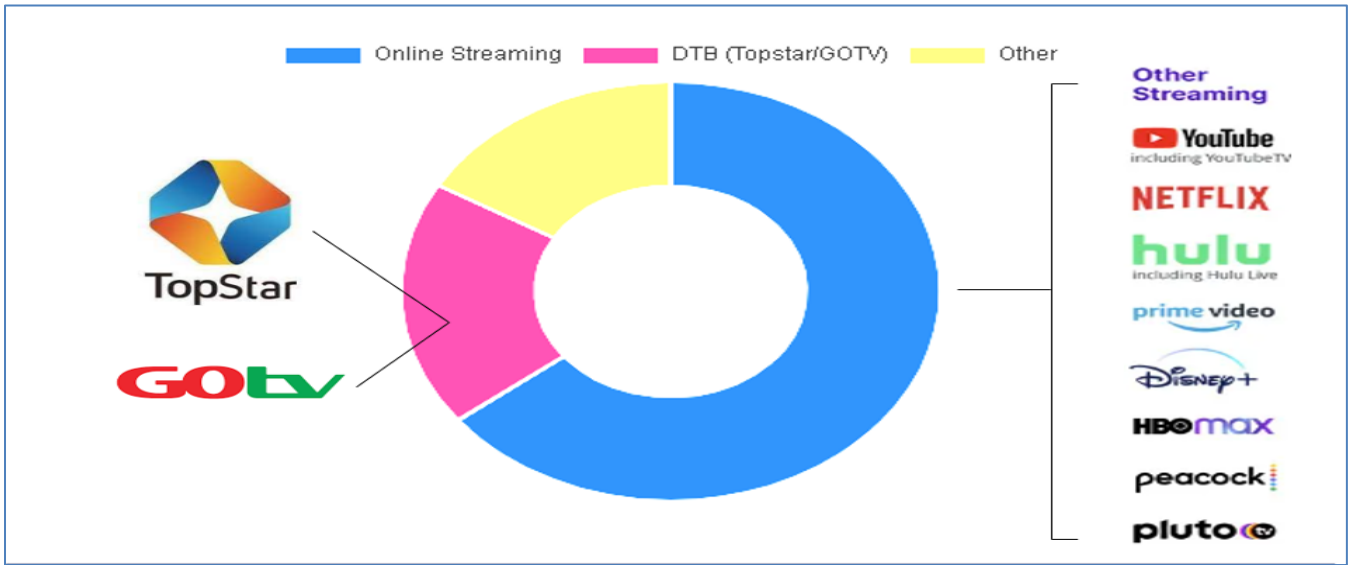


Fig. 10: Which service do you prefer overall?
(121 out of 171 respondents answered this question. 50 were without data)
Source: Author

According to Digital TV Research (2021), revenues for pay-DTB services in Europe are predicted to drop 40% by 2025 and 70% by 2030. In contrast, global OTT streaming revenues are estimated to reach $332 billion by 2026, more than double 2020 levels.

The survey results demonstrate audiences strongly prefer the convenience, flexibility and personalization of on-demand streaming content (Jesenko & Womersley, 2022).

DTB operators face urgent challenges to retain relevance amidst changing viewer habits (Jesenko& Womersley, 2022). Integrating streaming capabilities and emphasizing differentiated local and live programming could help broadcasters adapt to the streaming era (PwC, 2021). But the long-term dominance of streaming as the preferred viewing method presents an existential threat to traditional television business models.

- *Specific Objective 2:* To Assess and recommend new technologies that DTB networks can leverage on to enhance service delivery

- *Research Question:* How can DTB networks leverage on emerging technologies to enhance service delivery and stay competitive in the evolving media landscape?

- *Principle: Radio frequency spectrum is a finite and scarce resource requiring sustainable and efficient utilization to enable the wireless services and connectivity that modern society depends on.*

As a limited natural resource, frequency spectrum enables vital wireless services including mobile networks, broadcast distribution, satellite communications, emergency services, and much more. Yet available spectrum is increasingly congested and contested. Network operators like mobile and broadcast carriers require sufficient spectrum resources to support rising consumer demands for data-heavy applications and services. However, spectrum is not limitless, and its irrational or inefficient use leads to congestion, service degradation, stifled innovation and inability to expand access.

Network operators face growing challenges to meet rising consumer demands while controlling costs. Mobile network operators (MNOs) in particular struggle with expanding CAPEX and OPEX burdens driven by investments in new network infrastructure like 5G, rising energy costs, and pressure to deliver high-quality experiences to satisfy customers. At the same time, broadcast network operators (BNOs) have underutilized network resources and spectrum that could enable new services and business models. Emerging technologies like 5G broadcast offer innovative solutions to these issues through supplemental downlink capabilities and multicast transmission models

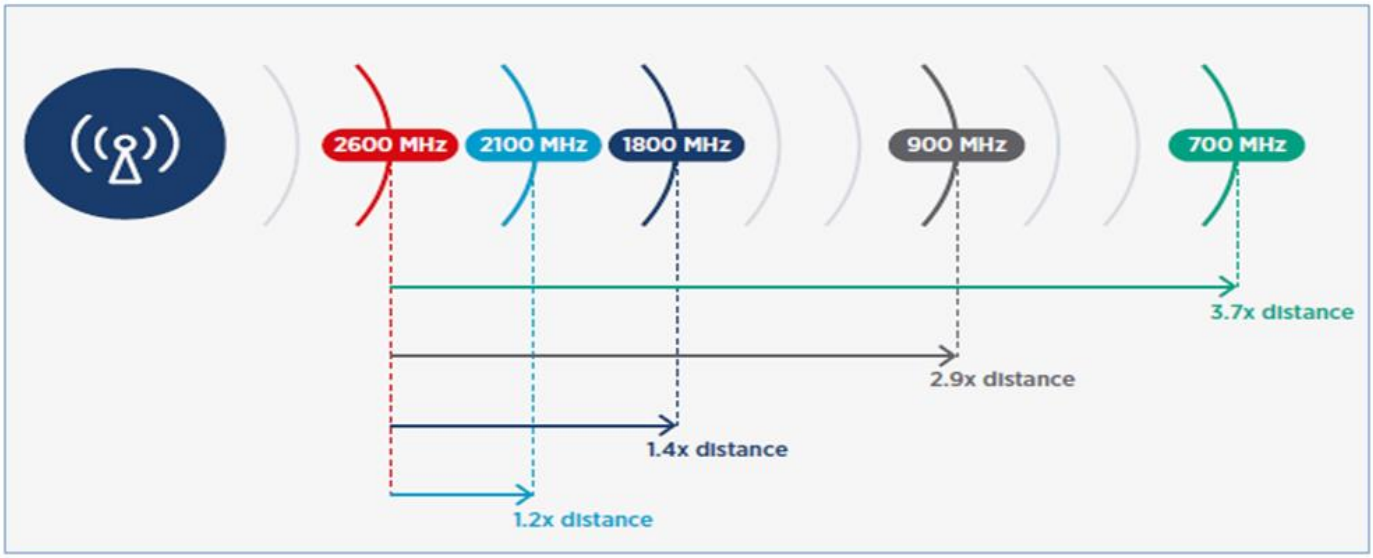


Fig. 11: Coverage comparison by Spectrum Band
Source: Author

➢ *Available and unused UHF Broadcast Radio Spectrum*

Out of the total UHF (470 – 694 Mhz) broadcasting band channels in Zambia 89.79% is unused and that there is room for deployment of two-way data communications networks using these frequencies. Chisumbe (2020).

Even after digital migration, mobile network operators (MNOs) are still eager to acquire more spectrum below 1 GHz (1000 Mhz) to address their challenges with growing demand for data capacity.

Radio Spectrum below 1GHz can cost effectively address Mobile Network use cases requiring wide and deep coverage (e.g. IoT, Last-mile Fiber in the Air, Rural use cases).

➢ *The Challenges Facing Mobile Network Operators*

MNOs worldwide are encountering difficult market dynamics that strain their technical and financial resources:

- **Surging network investment costs:** Deploying new infrastructure like 5G small cells is extremely expensive, with a 5G base station estimated to cost 3-4 times more than 4G LTE. China Mobile projects spending an average of $57,000 per 5G base station, meaning nationwide deployment represents billions in capital expenditure.

This comparative cost per base station is direct relation to the coverage comparison by spectrum band. Lower frequencies have superior propagation characteristics, determining how far a signal can travel and how well it can penetrate buildings. For example, using 700 MHz instead of 1800 MHz produces a path loss gain of 13.4 dB, thus creating better indoor and wide-area coverage. (Figure 11).

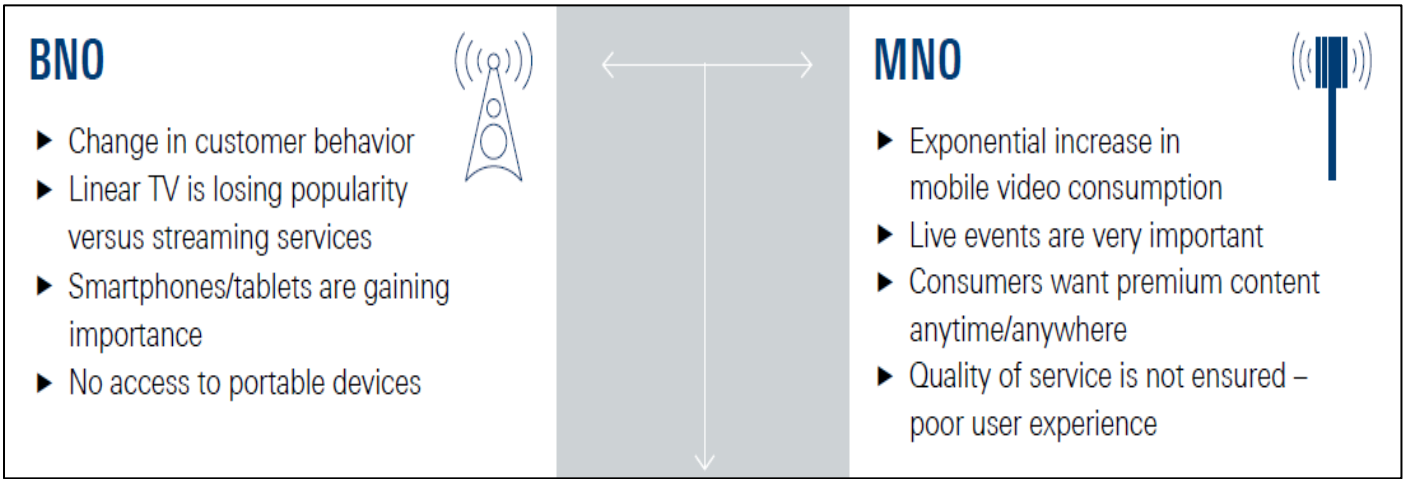


Fig. 12: Challenges Facing Broadcasting Network operators and Mobile Network Operators
Source: Author

- **Growing energy burden:** The power consumption of a 5G base station is 3 times higher than 4G, from 4-6 kW to 12-16 kW. With power accounting for ~20% of operating costs, the energy footprint of 5G will have a major OPEX impact.

- **Meeting consumer demand:** Customers expect continuously improving experiences, especially for bandwidth-heavy applications like video streaming. Network congestion easily degrades quality, so operators must overprovision to manage peak demand.
- **Coverage and congestion issues:** Outages from equipment failures or congestion during peak events frustrate customers. Cellular networks are prone to congestion and difficult to expand due to small coverage areas.
- **Inefficient capacity provisioning:** Operators struggle to match capacity to dynamic demand patterns. Overprovisioning capacity is expensive, while under provisioning risks service quality and customer dissatisfaction.

As shown in Figure 12 above, the interconnected challenges highlight the need for innovative solutions that optimize network efficiency, reduce energy consumption, and enhance service quality. New technologies like network slicing, intelligent infrastructure management, and dynamic resource allocation can help MNOs navigate these complexities and deliver a superior 5G experience to their customers.

➢ *The Promise of 5G Broadcast/Multicast*

Supplemental downlink (SDL) capabilities in 5G let MNOs offload bandwidth-intensive services like live video to broadcast networks, relieving congestion and ensuring consistent quality:

- **Hybrid Unicast/Broadcast Delivery:** 5G broadcast complements existing unicast cellular infrastructure, handling one-to-many traffic more efficiently.
- **Congestion Relief:** Large audiences for live events easily overwhelm unicast networks. Offloading to broadcast networks prevents quality degradation from congestion.
- **Efficient Large-Scale Distribution:** Multicast/broadcast transmission minimizes duplication across the access network, reducing costs.
- **High Bandwidth Services:** Linear TV and live streaming benefit most from broadcast networks suited for efficient delivery of continuous flows of bandwidth-heavy content.
- **Business Model Innovation:** New network monetization strategies become possible, like multicast as a service (MaaS) arrangements between operators.

Rohde & Schwarz has outlined capabilities needed to enable broadcast-quality live video delivery:

- Minimized delay (1-2 sec)
- Broadcast reliability
- Small cell offload to supplemental downlink
- Broadcast-level quality of service
- Multi-channel delivery origins
- Targeted ad capabilities
- Support for diverse verticals

A hybrid network combining existing unicast infrastructure with supplemental downlink broadcast delivery can provide the quality, reliability, and efficiency needed to manage rising network demands.

➢ *New Opportunities for Broadcast Operators*

While MNOs stand to benefit greatly from supplemental downlink capabilities, BNOs also gain new possibilities from 5G broadcast:

- **Flexible capacity provisioning**: BNOs can allocate bandwidth dynamically based on changing demand instead of keeping all channels active 24/7. This improves energy efficiency and allows expanding services without added spectrum costs.
- **Multicast as a service (MaaS):**BNOs could offer MaaS arrangements, allowing MNOs flexible access to broadcast infrastructure and spectrum resources to offload supplemental downlink traffic as needed. This generates revenue from previously underutilized network assets.
- **Expanded service portfolio:** Using broadcast networks for multicast services beyond linear TV, like automotive data or IoT communications, creates new market opportunities.

By enabling more flexible and efficient use of broadcast networks, 5G broadcast unlocks new technical capabilities and business models for BNOs. Shared infrastructure and cooperative relationships with MNOs via MaaS and supplemental downlink represent a potential win-win scenario.

The broadcast capabilities introduced with 5G allow both MNOs and BNOs to adopt innovative technical solutions and business strategies:

- **MNOs** gain supplemental downlink offload options to manage network congestion and ensure consistent service quality as data demand rises.
- **BNOs** can use their networks more dynamically to reduce operating costs and offer new revenue-generating services.
- Cooperative relationships between operators, like MaaS arrangements, enable resource and infrastructure sharing for mutual benefit.
- A combined unicast/broadcast delivery model balances efficiency and flexibility across converging media distribution networks.

Figure 13 illustrates Rhodes and Schwarz's end-to-end 5G broadcast/multicast solution architecture. It enables network operators to leverage 5G networks for one-to-many content delivery.

The solution utilizes a 5G broadcast/multicast generator server that formats and packetizes the source content. This content is then transmitted through a 5G next generation NodeB (gNB) using the 5G New Radio (NR) interface.

To reach mobile devices, the 5G NR signal passes through a regular unicast 5G network. For fixed devices, the signal goes through a broadband network gateway and WiFi access point using eMBMS over LTE or 5G broadcast technology.

Reception of the 5G broadcast/multicast signal on mobile devices is enabled by a pre-integrated 5G chipset support. For fixed devices, a broadband home gateway receives and processes the signal which is accessed on connected smart TVs or set-top boxes.

Key benefits of the solution include efficient high-bandwidth one-to-many distribution, reduced network congestion, and the ability to concurrently support broadcast, multicast and unicast services over 5G infrastructure.

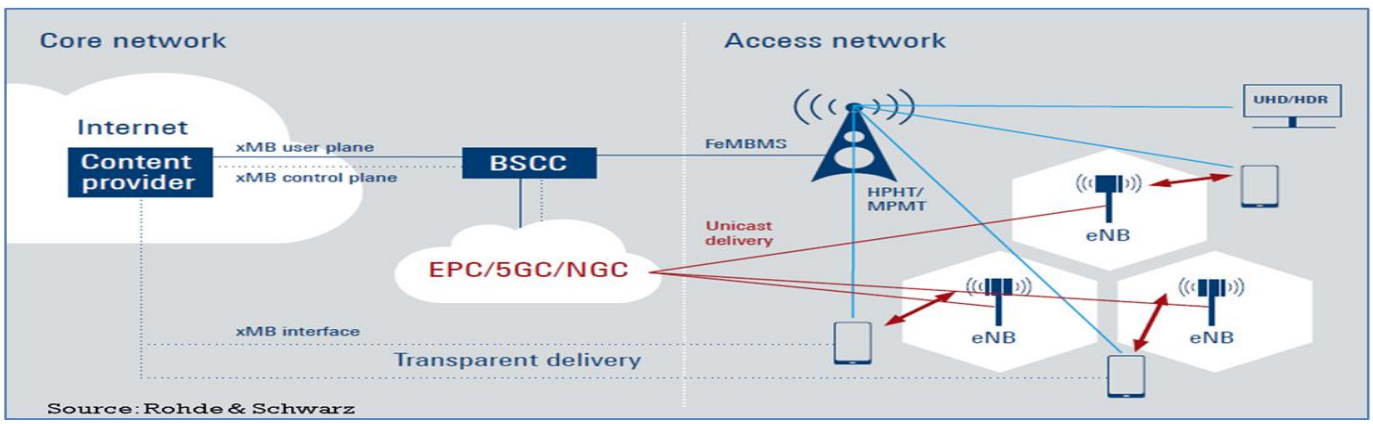


Fig. 13: Rhodes & Schwarz 5G broadcast/multicast Solution
Source: Rhode & Schwarz

- *Specific Objective 3:* To Evaluate and recommend regulatory measures to ensure sufficient spectrum is available for DTB.

✓ *Research Question:* What are the regulatory measures that can be considered to ensure the availability of sufficient spectrum for DTB networks, contributing to their operational efficiency and quality of service?

- *Principle: Radio frequency spectrum is a finite and scarce resource requiring sustainable and efficient utilization to enable the wireless services and connectivity that modern society depends on.*

The 2023 World Radio communication Conference (WRC-23) (International Telecommunication Union, 2023) shaped the future of the remaining UHF spectrum band (470-694 MHz) used for digital terrestrial broadcasting (DTB) in ITU Region 1 (covering Africa, Europe, and the Middle East). This band, previously reallocated for mobile services in part, faced further proposals at WRC-23: a co-primary allocation to mobile services or repurposing portions for 5G networks, potentially impacting DTT services significantly (International Telecommunication Union, 2023).

➢ *Importance of UHF Spectrum for DTB*

The UHF band's unique propagation characteristics enabled near-universal DTB coverage at an affordable cost (ITU, 2012). DTB provided free-to-air television, a platform for local content and emergency communications, crucial for public service broadcasting (UNESCO, 2014).

In many African countries, DTB rollout remained ongoing, with the analogue switch-off incomplete (Baldon& Musa, 2019). Re-allocating the sub-700 MHz band would have denied these countries the chance to complete DTT migration, stranding investments and forcing consumer equipment upgrades (ITU, 2012).

➢ *Importance of UHF Spectrum for 5G*

The sub-700 MHz band offered wider 5G coverage compared to higher frequencies, enabling better indoor penetration and rural connectivity, crucial for applications like smart cities, the Internet of Things (IoT), and Industry 4.0, requiring reliable and ubiquitous connectivity (GSMA, 2019). Studies in Europe indicated declining DTB usage, suggesting underutilization, and potential for repurposing parts of the band to accelerate 5G deployments and enable new use cases (European Commission, 2020). However, compatibility studies highlighted challenges with co-existing DTB and 5G in the same band (Ofcom, 2020).

➢ *Balancing the Needs*

A balanced approach has been necessary to address the spectrum needs of both broadcasters and mobile operators. One option, favored by developing countries, was a "no change" stance to the existing allocation until actual long-term spectrum needs are determined (Baldon& Musa, 2019). Additionally, secondary mobile allocations within the band could enable case-by-case shared use where feasible (ITU, 2022).

Further studies on spectrum sharing were recommended to assess DTB-5G compatibility based on real-world deployments. The challenges faced by developing countries implementing DTB also required consideration before making changes to the UHF band (ITU, 2022). The WRC-23 decisions on the UHF band acknowledged the need for a flexible framework that could:

➢ *Allow continued DTB services in areas reliant on them.*
➢ *Gradually open the UHF band for 5G where underutilized by broadcasting.*

This required compromises from both broadcasters and mobile operators to ensure fair access to spectrum and continued development of both broadcasting and mobile communication technologies.

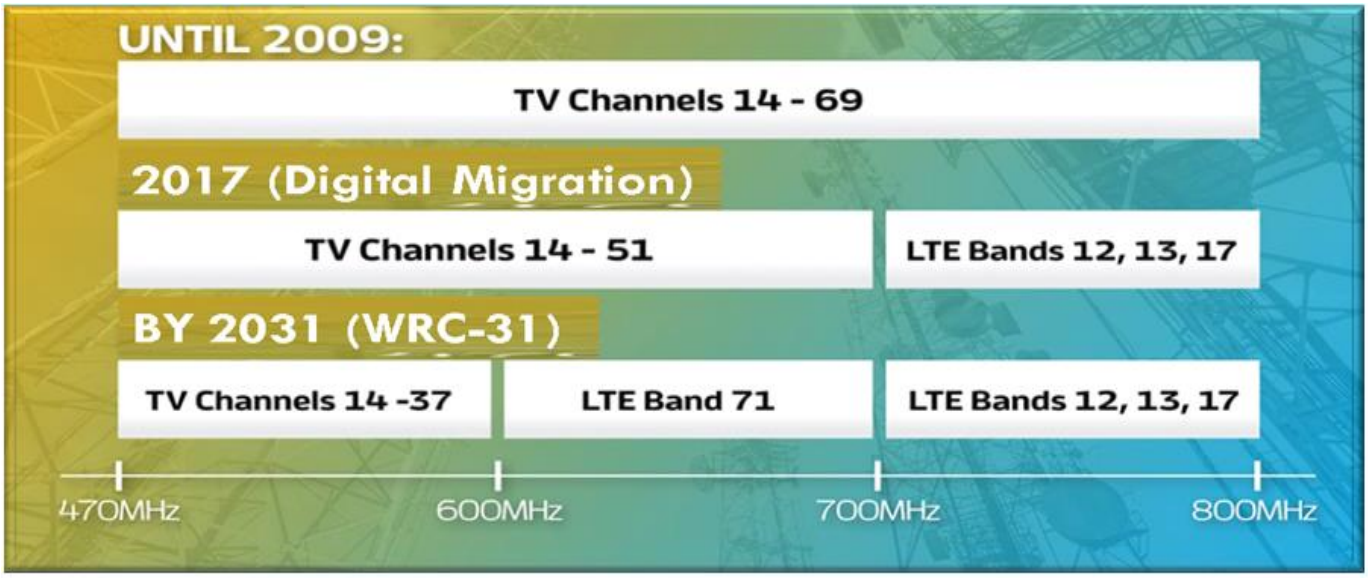


Fig. 14: Evolution of TV channels and LTE bands in the sub-700 MHz
Source: Author

Figure 14 is a description of the picture that shows the evolution of TV channels and LTE bands in the sub-700 MHz band from until 2009 to a projected state by the year 2031. It explains how the spectrum allocated to TV broadcasting has been reduced over time to make room for mobile services, such as LTE and 5G, and how the World Radiocommunication Conference (WRC) has been the key event that has shaped this process.

In conclusion, emerging 5G broadcast technologies offer innovative solutions to enhance DTB service delivery and empower broadcasters to remain competitive. 5G broadcast enables supplemental downlink capabilities, allowing DTB operators to offload bandwidth-heavy content to optimize network efficiency. Multicast transmission models are better suited for continuous linear broadcasts compared to unicast.

For mobile network operators facing surging data demands and congestion issues, 5G broadcast offers welcome relief via broadcast offload. This prevents quality degradation during peak events. For broadcasters, 5G allows more dynamic network utilization and creates possibilities for new revenue streams through multicast-as-a-service arrangements. Collaborative relationships between DTB and mobile operators can be mutually beneficial.

To fully leverage 5G broadcast's potential, regulators should ensure sufficient spectrum access for supplemental downlinks. Overall, 5G broadcast can enhance DTB service quality, network flexibility and monetization opportunities. But continued infrastructure investment and industry cooperation is vital for 5G broadcast to fulfill its promise of converging broadcasting and mobile broadband.

IV. DISCUSSIONS

This section will inter pretend discuss the results presented in the previous chapter. The discussion will be done in sub sections by objective.

- *Objective 1: Business Models*

The findings from the survey data provide valuable insights into the factors influencing declining DTB subscriptions and the measures needed to revitalize the platform. The strong preference for online streaming services due to superior video quality, content variety, and on-demand access clearly indicates the challenges facing traditional broadcast models. This aligns with global trends of viewers migrating to OTT platforms (Lombardo, 2017).

However, the survey also revealed opportunities for broadcasters to remain competitive by adopting targeted strategies. Enhancing content diversity, improving service quality, reducing costs, and leveraging streaming partnerships were emphasized by respondents as ways DTB could meet evolving audience demands. The interest in technological innovation also shows viewers value broadcast platforms keeping pace with advancements.

These findings confirm conclusions from scholar Chanda (2020) that DTB operators must embrace changes in technology, business models, and regulations to thrive amidst disruptive changes in media consumption patterns. The demand for continuous improvement of quality, flexibility and affordability indicates broadcasters cannot rely solely on the status quo.

Additionally, leveraging partnerships with streaming platforms represents a major opportunity to converge broadcast and online delivery. Offering multi-platform access and on-demand libraries in tandem with live programming could provide an advantage over OTT services. These findings align with Mbewe (2021), who advocates partnerships between broadcasters and telecom providers.

- *Objective 2: Emerging Technologies.*

The assessment of emerging technologies highlighted the promise of 5G broadcast to create win-win scenarios for both mobile and broadcast operators. Its supplemental downlink capabilities offer congestion relief for mobile networks while enabling broadcasters more efficient use of spectrum and infrastructure. However, fully realizing these mutual benefits requires active collaboration between operators, such as in MaaS partnerships.

The analysis of 5G broadcast technology demonstrated its potential to create mutually beneficial outcomes for both mobile and broadcast operators. Offloading supplemental downlink traffic to broadcast networks relieves congestion and capacity constraints for mobile operators as data demand rises. For broadcasters, 5G broadcast enables more efficient use of spectrum and infrastructure through flexible provisioning.

However, these win-win scenarios depend on active collaboration and infrastructure sharing between operators. The case studies in Nigeria (Ogbole, 2020) and South Africa (Mokgobu, 2022) highlight the promise of multicast/broadcast partnerships but also the need for supportive regulatory frameworks. More research is required on optimal business models and policy approaches.

- *Objective 3:Regulatory Measures*

Regulatory analysis showed broadcast spectrum faces rising pressure from mobile broadband, but counterarguments emphasize its continued importance for public service mandates. The WRC-23 decisions tried balancing both sectors' needs. Gradual, flexible framework changes allow time for broadcasters to adapt while opening spectrum where underutilized. However, this requires compromise from both sides and further technical sharing studies.

The examination of spectrum allocation debates showed the complex balancing act facing regulators between broadcast and mobile sectors. While the sub-700 MHz band offers advantages for rural 5G rollouts, re-allocation before DTT migration completion risks stranding investments in developing countries. Gradual, market-driven approaches

allow time for broadcasters to adapt while utilizing spectrum more efficiently.

However, as Chaponda (2019) notes, decisions favoring mobile allocations ultimately seem inevitable given the pace of technology shifts. Broadcasters must innovate services within the spectrum available while regulators conduct ongoing sharing studies. Clear roadmaps from regulators enabling broadcast evolution would aid this process.

V. CONCLUSION AND RECCOMENDATIONS

A. Conclusion:

The This study underscored the disruptive impacts of changing viewer habits and emerging technologies on Zambia's DTB sector. Broadcasters now face an imperative to rapidly enhance programming, video quality, flexibility and affordability via partnerships and platform convergence. Additionally, collaborative relationships with telecom operators to deploy 5G broadcast can create mutual benefits but require supportive policy frameworks.

As spectrum pressures rise, regulators must balance safeguarding public service broadcasting mandates while freeing underutilized spectrum incrementally. More research on optimal sharing models is vital. Overall, proactive innovation maximizing content, technology and partnerships is essential for Zambia's DTB sector to flourish amidst digital disruption. Regulators also need clear roadmaps allowing broadcasters time to adapt to inevitable mobile-driven reallocations.

With visionary leadership and collaboration, Zambia's broadcast industry can retain its vital societal roles while embracing new opportunities. This study provided key strategies and recommendations to guide stakeholders in securing DTB's future sustainability and competitiveness.

B. Recommendations:

- *Develop clear policies and transition plans:*

Regulators should work with broadcasters to develop clear policies and multi-year transition plans that provide a roadmap for the evolution of DTB networks. This allows sufficient time for adaptation while opening spectrum incrementally based on utilization rates and sharing studies.

- *Incentivize infrastructure sharing and partnerships:*

Policies that encourage infrastructure sharing and public-private partnerships between telecom and broadcast operators can accelerate deployment of technologies like 5G Broadcast. Regulators can enable this through unbundling, open access frameworks, and incentives for cooperative relationships.

- *Invest in audience research and pilot studies:*

Ongoing audience research provides vital data to broadcasters on evolving viewer needs and preferences. Regulators should support industry pilot studies on new services, business models and technologies to build empirical evidence prior to policy changes.

- *Promote digital literacy and local content development:*

As new platforms emerge, continued public media literacy efforts ensure citizens can access services. Support for local content production also aids broadcasters in competing with global streaming giants through differentiated programming.

- *Develop supportive universal service policies:*

Regulatory universal service programs, such as subsidies or tax breaks targeted at broadcast operators, can assist their transition and continued delivery of public interest mandates as competitive pressures rise.

REFERENCES

[1]. Bwalya, E., & Mutale, M. (2022). *Digital migration in Zambia: Who are the real beneficiaries?* International Journal of Scientific and Research Publications, 12(7).
[2]. Government of the Republic of Zambia (GRZ). (2014). Ministerial statement on the progress made on implementation of the digital migration project. Ministry of Information and Broadcasting Services.
[3]. Gulyaev, A. (2017). Huawei views on the use of the 470-694 MHz band for IMT. ITU-D Regional Seminar, Rome.
[4]. African Telecommunications Union (ATU). (2022). *Preparations towards WRC-23*. https://www.atuuat.africa/2022/05/30/preparations-towards-wrc-23/
[5]. Jesenko, A. & Womersley, R. (2022). *Study on the use of the sub-700 MHz band*. European Commission.
[6]. Lombardo, M. (2017). *The evolution of digital terrestrial distribution*. European Broadcasting Union.
[7]. Macauhub. (2019). *Pay-TV operators in Mozambique register very low market penetration*. http://www.macauhub.com.mo
[8]. Ministry of Information and Broadcasting Services (MIBS). (2017). *Digital migration infrastructure project*. Government of the Republic of Zambia.
[9]. Rohde & Schwarz. (2021). *5G broadcast/multicast*. https://www.rohde-schwarz.com.
[10]. Zambia Information and Communications Technology Authority (ZICTA). (2021). *Annual report 2021*. https://www.zicta.zm/
[11]. Lombardo, S. (2017). The threat of online video platforms on terrestrial broadcasters. International Journal of Digital Television, 8(3), 307-323. https://doi.org/10.1386/jdtv.8.3.307_1
[12]. Bwalya, K., & Mutale, G. (2022). Factors affecting adoption of digital terrestrial television by viewers in Lusaka district of Zambia. International Journal of Technology and Educational Marketing, 10(1), 1-15. https://doi.org/10.4018/IJTEM.282581
[13]. Chanda, B. M. (2020). Digital migration in Zambia: The challenges facing digital terrestrial television. Masters Thesis, University of Zambia. http://dspace.unza.zm/handle/123456789/6893

[14]. Chisumbe, F. (2020). Radio spectrum occupancy measurements and status in the digital dividend in Zambia. Zambia ICT Journal, 3(1), 26-31. https://ictjournal.ictaz.org.zm/index.php/ictjournal/article/view/23
[15]. Mbewe, A. J. (2021). Managing the challenges of digital migration in Zambia. Digital Policy, Regulation and Governance, 23(4), 369-390. https://doi.org/10.1108/DPRG-04-2021-0039
[16]. Ogbole, J. (2020). Business collaboration models for 5G multicast/broadcast services in Nigeria. Proceedings of the 2020 ITU Kaleidoscope Academic Conference, pp. 1-8. https://doi.org/10.23919/ITUK50373.2020.9232214
[17]. Mokgobu, T.A. (2022). Techno-economic analysis of multicast/broadcast services as network offloading solution. Masters Thesis, University of South Africa. http://hdl.handle.net/10500/29808
[18]. Chaponda, T. (2019). Digital dividend - The Zambian perspective. Digital Policy, Regulation and Governance, 21(6), 569-582. https://doi.org/10.1108/DPRG-07-2019-0053
[19]. Baldon, M. A., & Musa, P. N. (2019). Digital Terrestrial Television in Africa: Challenges and Opportunities. *International Journal of Communication*, 13(1), 213-233.
[20]. European Commission. (2020). 5G for Europe: An Action Plan. https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52016DC0588
[21]. GSMA. (2019). The Mobile Economy Africa 2019. https://www.gsma.com/subsaharanafrica/resources/the-mobile-economy-sub-saharan-africa-2019
[22]. International Telecommunication Union. (2012). Technical Considerations for the Use of the UHF Band (470-694 MHz) for Broadcasting. https://www.itu.int/dms_pubrec/itu-r/rec/bt/R-REC-BT.1877-3-202012-I!!PDF-E.pdf
[23]. International Telecommunication Union. (2023). Final Acts of the World
[24]. Digital TV Research (2021). Global OTT TV & Video Forecasts. https://www.digitaltvresearch.com/products/product?id=270
[25]. Jesenko, M. & Womersley, R. (2022). The future of broadcast television: OTT dominant, complementary or extinct? Deloitte Insights. https://www2.deloitte.com/xe/en/insights/industry/technology/technology-media-and-telecom-predictions/2022/future-of-broadcast-television.html
[26]. PwC (2021). Perspectives from the Global Entertainment & Media Outlook 2020–2024. https://www.pwc.com/gx/en/industries/tmt/media/outlook.html