# Investigating Spectrum Allocation Policies to Accommodate New Entrants in the Market: A Case Study of South Africa

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**Abstracts:** One of the goals of the telecommunications industry is to provide universal connectivity to its consumers. Achieving this goal is highly dependent on the allocation of radio frequency (RF) spectrum. The RF spectrum refers to the frequencies assigned to diverse services such as mobile, fixed, and satellite services. These allocations are regulated by international, regional, and local authorities. Countries across the globe have embarked on the journey to transform their RF spectrum allocation policies to be more inclusive and hybrid in nature. Such changes in some countries, have enabled new entrants and incumbent operators to provide low-cost connectivity into small rural communities, bridging the digital divide gap. Due to current policies by some regulators and perceived anti-competitive laws, new entrants and small operators find it difficult to penetrate the telecommunications market in South Africa. To address this challenge, the overall and ongoing study, proposes an alternative and inclusive framework for universal coverage and low-cost connectivity that accommodates both incumbent and new entrant operators in South Africa. To achieve this aim, a qualitative desktop research approach was used to analyze publicly available information, including journal articles, RF spectrum policy documents from various countries, International Telecommunication Union (ITU) documents and other academic sources. The objective of this paper is to contribute to the ongoing discussions regarding the policy on the allocation of RF spectrum. As this is an ongoing study, preliminary findings indicated that auctions remain a popular RF spectrum allocation model of choice, despite being perceived by some scholars as less competitive and inflexible. The final study findings, which would be in a subsequent research paper, aim to develop a new RF spectrum framework that may help achieve universal coverage and low-cost connectivity in South Africa.

**Keywords:** Connectivity, Radio Frequency Spectrum, Models, Spectrum Assignment Policy, Telecommunications Industry.

## 1. INTRODUCTION

Over the past two decades, there has been a huge expansion in the telecommunications industry to absorb more customers through voice and data services (Nir and Nikhilesh, 2018). Customers are demanding large volumes of data services, which has resulted in the network congestions and great demand from customers residing in the areas where there is insufficient and no network infrastructure coverage. A radio frequency (RF) study conducted by the International Telecommunication Union (ITU), which is the regulatory body for RF spectrum management, has revealed that the COVID-19 pandemic has also exerted more pressure on the network, as most businesses are operating remotely (ITU, 2022). This requires more broadband with a high-capacity transmission technique using a wide range of frequencies, which enables many messages to be communicated simultaneously and improved speed to ensure less distractions on the business and connectivity (ITU, 2022). Due to the growing technology adoption and dependency by business this has made the telecommunications industry to be a driver for productivity across economies and societies (Lewis,2020).

In this regard, RF spectrum has been identified as a key factor for broadband and universal coverage (ITU, 2016). Electromagnetic frequency spectrum is usually explained as *“a finite national and global resource that needs to be managed in the public interest in order to derive the greatest benefit to the entire population”* (ITU, 2019:18). Nozdrin (2021) describes RF spectrum as the electromagnetic frequency continuum ranging from 30 kHz to 300 GHz, which plays a crucial role in connecting people using wavelengths. A study conducted by the Global System for Mobile Communications Association (GSMA) added that, spectrum relates to the radio frequencies allocated to a service such as mobile services, fixed services, and satellite services (GSMA, 2019). This is a natural resource which is transformed into an entity to connect people and unlock the economic value of telecommunications (GSMA, 2020).

The RF spectrum as a scarce natural resource requires effective management and regulation to avoid interference and RF spectrum wastage (Nozdrin, 2021). This is the reason why this scarce resource is managed by different regulatory bodies at the international, regional, and local levels. Examples of these regulatory bodies span multiple levels. At the international level, the ITU is a key player. Regional bodies include the African Telecommunications Union (ATU) and the Arab Spectrum Management Group (ASMG). Intra-regional entities, such as the One Network Area (ONA) and the Telecommunications Regulators' Association of Southern Africa (TRASA), also play a significant role. On a local level, authorities such as the Independent Communications Authority of South Africa (ICASA), the Telecom Regulatory Authority of India (TRAI), and the Federal Communication Commission (FCC) are instrumental.

The ITU (2016) defines RF spectrum management as the application of technical and regulatory mechanisms to augment the use of RF spectrum in electronic communications through multidisciplinary approaches including knowledge of international politics, policy, regulation, economics, and engineering. Other scholars argue that innovative approaches to RF spectrum management are required. Pogorel (2017) debated that, issues such as the mounting tension on governing resources, deficiencies of the conventional and centralized approach to RF spectrum management have been made superficial, resulting into governments looking for new models to RF spectrum assignments. Gillwald, Mothobi and Rademan (2018) concurred with this argument from Pogorel (2017) by asserting that reforms are needed in the RF spectrum management sphere to regulate and allocate spectrum to its optimal usage and cover a wider population. RF spectrum allocation play a crucial in RF spectrum licensing. RF spectrum allocation is defined as a process of regulating the usage of the electromagnetic spectrum, where it is divided amongst allocated operators (Lewis, 2020). This process ensures that specific RF spectrum bands belong to competing operator and it is not used for unregulated purposes. There are different types of RF spectrum assignment models that are used by various regulators.

The RF spectrum assignment models that are normally used are auctions, beauty contests, first come first serve and lotteries (Song, 2017). In a beauty contest, a commission naturally defines standards to be used, with different weightings (Ratier, 2014). Candidates offers are evaluated by a committee that selects the best suitable candidate based on the weightings. The beauty contest model sets up purchase parameters such as financial resources, pricing, quality, technology, reliability, and the speed of network rollout (Hazlett, 2017). In contrast, RF spectrum auction is a competitive process where a regulator licenses the RF spectrum bands to bidders based on an auction process. This model usually benefits bidders with great financial resources and incumbents that are already in the industry (Nozdrin, 2019). The lottery model is known to be quicker and more economical as compared to auctions and beauty contest. This is the least used assignment model as it is perceived to have its own shortcomings. Jilani (2015) has argued that in the 1980s in United States of America (USA), the lottery model is known to have attracted many applicants of which most were lacking technical aptitude. These applicants were offered RF spectrum licenses, but they could not be able to use them due to the lack of technical ability. The incumbent firms ended up benefiting from these licenses at an excessive price, leading to notional losses to government funds. This makes this model to be less favorable. In addition, the first come first serve RF spectrum allocation is a model in which the RF spectrum is allocated to the first entity to request and obtain authorization to use it. In this model, no bidding process or other allocation mechanism is used (Liu and Sun, 2017). Different stakeholders in the telecommunications industry are openly criticizing RF spectrum assignment models used by different regulators, arguing that they are not inclusive and further provide no equitable usage (GSMA, 2020).

Furthermore, studies have revealed that auctions are mostly applied as a RF spectrum assignment model due to distinct reasons (Gillwald, Mothobi and Rademan, 2018). One of the common reasons is the pressure from governments and regulators to maximize profit when licensing the RF to the operators (Lewis, 2020). This is evident in South Africa (SA) where there has been a public criticism pertaining to the recent Fifth Generation (5G) technology RF spectrum assignment, where new entrants could not participate in the auction due to their lack of financial resources and company size (ITU, 2022). Furthermore, some telecommunications companies criticized this model as it is alleged that it perpetuates oligopoly to an extent that well-established entities with huge financial resources scored big in the bidding process while other smaller operators settled on smaller RF spectrum bands (Foster, 2017; Venkatram and Zhu, 2020; Lewis, 2020; Research ICT Africa, 2020).

On this note, some countries have already embarked on a journey to transform their RF spectrum assignment policies to be more inclusive and hybrid in nature. For example, in Canada, the regulator allocated RF spectrum to the incumbent operators and Non-Profit Organizations (NPOs). Study reveals that these NPOs are subsidized by the government to provide low-cost connectivity into small communities which are rural (Hadzic, 2019). In India, two new entrants had emerged as strongest competitors against the incumbent operators by focusing on rural connectivity (Hazlett, 2017). This occurred due to the government reserving the RF spectrum to new and late entrants. In Rwanda and Kenya, both countries transformed their RF spectrum policies to achieve a better broadband coverage strategy by introducing community operators as small entrants to service rural areas and urban areas (Song, 2017). This occurred through the passive infrastructure sharing for mobile backhaul.

According to Hadzic (2019), policy reform in South Africa's telecommunications industry is necessary to promote competition, universal coverage, and accommodate both new and struggling incumbents. However, few dominant players pose entry barriers for emerging operators due to regulatory policies and anti- competitive practices. Furthermore, limited access to RF spectrum allocation models limits universal connectivity in South Africa. This study aims to investigate South Africa’s current RF spectrum models that support both incumbents and emerging operators. The contribution of this study is vital to on-going discourse on RF spectrum allocation policy, with potential implications for similar connectivity challenges in other countries.

This paper is structured as follows: The introduction section of the paper comprises the background and problem statement, while Section 2 outlines a review of the literature on RF spectrum allocation models. Section 3 describes the study's methods, and Section 4 presents the results and offers a detailed discussion of the findings. Lastly, Section 5 concludes the paper.

## 2. LITERATURE REVIEW

### 2.1. Radio Frequency Spectrum

The electromagnetic spectrum is the range of all types of electromagnetic radiation (Bhat, 2020). Radiation is energy that travels and spreads out as it goes (Mladenoff, Finkenstadt & McMurray, 2020). Furthermore, the electromagnetic spectrum is divided into different bands, each with its own range of frequencies. The bands are (Sentsov, Bukaeva & Neuimina, 2021):

- Radio waves
- Microwaves
- Infrared
- Visible light
- Ultraviolet
- X-rays
- Gamma rays

According to Mladenoff et al. (2020), radio waves are a type of electromagnetic radiation that have a frequency ranging from 3 Hz to 300 GHz. The RF spectrum is the portion of the electromagnetic spectrum that is used for radio waves (Bhat, 2020). Moreover, the RF spectrum is used for a variety of applications, including (Sentsov et al., 2021):

- Radio broadcasting
- Cellular networks
- Wi-fi

- Satellite communications
- Radar
- Medical imaging

In this paper, we focus on RF spectrum. The RF spectrum is becoming progressively scarce, with public safety requiring a share of the resource while facing competition from commercial interests (Fisher, van der Merwe, & Fehr, 2019). Sims (2017) notes that radio frequencies have lower energy levels when compared to visible light and other forms of electromagnetic radiation. These frequencies can be modulated to convey information, transmitted, and decoded at a remote location. However, the suitability of different radio frequencies varies based on features such as building penetration, propagation range, resistance to atmospheric conditions, power efficiency, digital capacity, or antenna size (Sutherland, 2018). The electromagnetic energy frequencies used for communication purposes cover a range of frequencies, as demonstrated in the figure below.


**Fig. 1:** Overview of radio frequency spectrum, adapted from Davies (2015)

The RF spectrum is illustrated and briefly described in Fig 1 above. Low frequency (LF) and medium frequency (MF) bands range from 3 kilohertz to 3 megahertz, or wavelengths of 100 km to 100 meters, starting at very low frequency (VLF). These frequencies are utilized for low-bandwidth analog services like maritime telegraph and distress channels, long-distance radio navigation, and regular AM radio broadcasts.High-frequency (HF) radio operates between the frequencies of 3 and 30 megahertz in the 100 to 10-metre wavelength range. Mobile and fixed voice communication services needing transmission bandwidths use a large portion of the HF spectrum. Televisions and FM radio are operating on a very-high frequency (VHF),between wavelength range of 10 metre to 1 metre and frequencies 30 megahertz and 300 megahertz. Ultra- high frequency (UHF) band is used for television, mobile phones, microwave line-of-sight links and Global Positioning System (GPS) (Sims, 2017). According to Bath (2020), RF spectrum for telecommunications start operating from UHF band. Moreover, the centimeter to millimeter wavelength range, which spans frequencies of 3 gigahertz to 300 gigahertz, is where the superhigh frequency (SHF) to extremely high frequency (EHF) bands are located. The SHF band typically has assigned bandwidths between 30 and 300megahertz, allowing for high-speed digital communications (Sentsov et al., 2021). Sutherland (2018) argued that EHF band is currently the least populated radio band for terrestrial communication.

### 2.2. Spectrum Management

Spectrum management is the most crucial part of RF spectrum licensing as it deems to ensure the treaty on the usage of RF spectrum and eliminates interference. RF spectrum assignment to services is done on the global scale through the ITU- Radiocommunication (ITU-R). Depending on the ITU-R Region (for example, regions 1, 2 and 3) to which it belongs (for example, Africa, Middle East and Europe), an Administration (read "country") then formulates RF spectrum assignment policies which generally involve adopting by reference the Final Acts of the World Radio Conference (WRC), which take place every three to four years to evaluate, and, if required, review the radio regulations, the international accord governing the use of the RF spectrum and the geostationary-satellite and non-geostationary-satellite orbits (Sims, 2017). The Final Acts contain all the agreements of the WRC including the table of frequency assignments (ITU, 2022). A regulator then implements the Administration's RF spectrum assignment policies by formulating relevant regulations to license RF spectrum to operators. RF spectrum licensing gives the licensee the right to use the assigned RF spectrum (Sims, 2017). For mobile services, for example, the license can be valid for 10 years or more, subject to certain conditions, and during that period of validity of the license, the operator manages the distribution of the assigned RF spectrum to multiple base stations and areas of the country. Sometimes the RF spectrum license limits the geographic area(s) where the assigned RF spectrum can be used. For fixed services for example, point-to-point microwave, if the licensed frequency band is shared with other operators, national administrators manage individual frequency assignments to make sure that frequency interference is avoided (Song, 2017).

In managing RF spectrum, administrators are concerned with two procedures of competence: technical and economic efficiencies, which are pursued within the overall context of public policy (Sutherland, 2018). Technical efficiency is crucial in the RF spectrum management as it provides the guidelines for the effective usage of RF spectrum within acceptable interference limits (Sutherland, 2018). It also strives to encourage the expansion and introduction of RF spectrum-saving technologies. Economic efficiency on the other hand pertains to the value unlocked through the optimal allocation of RF spectrum. Sutherland (2018) further argued that this scarce resource must be used to its fullestpotential to maximize economic benefits.

### 2.3. Spectrum Allocation Models

There are four common models that are used by various administrators to allocate RF spectrum. These models are auctions, beauty contest, lottery and first come-first served (Janali, 2015). As discussed in the previous section, the purpose of RF spectrum management is to enhance the economic efficiency and technical ability of the RF spectrum. Then the administrators apply these models with the aim to achieve these abilities prescribed in the RF spectrum management goals and framework (Robb, 2017).

The beauty contest model which is known as the administrative process is usually designed by a government collaborating with a committee of experts to review various proposals considering the government laid criteria (Tadjadine, 2021). This process delivers a lot of flexibility to the regulator in determining the acceptance of a proposal that will work in harmony with government objectives. This process has been criticized to be time-consuming, but it has become a success in countries such as Canada (Jinali, 2015). Some experts and researchers are widely criticizing this criterion as having a lot of red tape and allocate RF spectrum politically to those who have proximity to government (Hazlett, 2018; ITU, 2019; GSMA, 2018)

On the other hand, the lottery model is alleged to be quicker and more economical as compared to the beauty contest model (Tadjadine, 2021). However, this model is seldom used as it is criticized on the basis that lotteries lead to assumptions and the technical capability of the operator to advance and operate the license. This is something which usually cannot be determined through the lottery model (Jinali, 2015). Mulas (2019) added that countries such as the USA had publicly criticized this model, claiming that some applicants get awarded RF spectrum licenses only to find out that they are not technically experienced. Consequently, some of these applicants sell their licenses at inflated prices to the other operators.

The first-come, first-served model is economical and time-efficient, but it is used less frequently (Sutherland, 2018). This model is like a lottery that may attract applicants who lack the necessary technicalskills, as noted by Janali (2015) in some European Union (EU) member countries that use it for mobile radio license assignment. This approach has the advantage of being quick, but it also has drawbacks, like the lottery, in terms of the allocation process. To overcome this issue, experts such as Davies (2015) suggest that administrators must strengthen requirements to ensure that the first applicant is not automatically allocated the RF spectrum, particularly if they lack the technical expertise.

The auction RF spectrum allocation model is a widely used and time-efficient model employed by several countries (Jilani, 2015). Foster (2017) supports this view by indicating that RF spectrum auctions are highly regarded as the international standard for RF spectrum assignment. However, the highest bidder is prioritized, which may exclude applicants without adequate financial resources. Auctions are market-based mechanisms for RF spectrum allocation, often employed to cope with the increasing demand for this resource (ITU, 2022). Several factors, such as economic development, investment climate, infrastructure development, demand for RF spectrum, and fewer restrictions on foreign ownership and trade, influence the decision to apply auctions or non-market-based RF spectrum assignment tools (Tadjadine, 2021). In addition, implementing an auction mechanism requires carefully crafted regulatory support (Mulas, 2019).The regulator must approve the RF spectrum band for auction, the available bandwidth, and the specific nature of the RF spectrum right, including coverage limits.

The auction model of RF spectrum allocation has been criticized for being unfair, as operators with economically deeper pockets are more likely to succeed by offering the highest bids (Sutherland, 2018). This is perceived to be lacking in competitiveness and disadvantages new entrants and those with fewer financial resources in the telecommunications sector (Mulas, 2019). The bidding process in FCC auctions allows bidders to bid for multiple RF spectrum licenses simultaneously and at different prices, increasing their chances of winning (Tadjadine, 2021). This feature tends to favor incumbents that have more financial resources to enable them to bid for multiple licenses.

Whereas the auction is the most suitable and favored model for RF spectrum allocation in divergence to other models, economists have endorsed a sharing of RF spectrum bands, and this is debated as giving user flexibility to transfer their RF spectrum rights so that the primary related economic efficacy of RF spectrum resource assignment can be maintained (GSMA, 2020). Foster (2018:24) has supported this view by adding that *"radio spectrum sharing result of several aspect such as technical, administrative, or commercial and spectrum can be shared in several dimensions: time, geography, or space dimension."* Furthermore, policymakers are arguing that a policy reform is needed in countries like South Africa (Venkatram and Zhu, 2012). For example, auction can be used as a flexible policy apparatus to address a variability of policy goals to accomplish socio-economical and market competition objectives. Foster (2018) argued that ICASA can decide to redress the past wrongs of RF spectrum assignment where some petitioning or collusive bidding was observed.

### 2.4. Gaps Associated with Existing Spectrum Models: International Comparability

Each country employs RF spectrum allocation techniques that suit its specific needs, as there is no universal approach. Valuable insights can be gained from assignment models used by EU countries. Klemperer (2017) notes that models used in the United Kingdom, Denmark, and Germany are effective, generate revenue, and create market diversification. These countries have successfully introduced new entrants into the market, diversified the telecommunications market, and achieved substantial revenue through RF spectrum licensing.

Countries such as Australia were faced with the failure in their assignment processes due to the collapse in auctions which resulted in the collusion between bidders (GSMA, 2019). Furthermore, countries such as Netherlands, Italy and Switzerland were unable to get new entrants into the market due to auction process that was used (Klemperer, 2017). Lewis (2020:13) criticized the process of auction by emphasizing that *"many spectrum auctions have failed, while others can be viewed as problematic."* This is evident in OfCom, where there were 150 bidders in the auction, but only five were winners and there was no new entrant. After this OfCom report Lewis (2020) then argued that this administrator made recommendations that there is a strong need to construct a review mechanism for the competitive operation of the telecommunications industry in the OfCom countries before auctions are considered. ITU (2019) supported this recommendation by indicating that the regulator must select strategies for imminent auctions through the assessments of bidders in terms of their financial and technical competencies.

In developed countries such as the USA, telecommunications operators are divided into telecommunications markets, where in big cities, there are big operators providing telecommunications services, while in smaller cities, smaller operators are subsidized by the regulators to provide connectivity. This bridges a gap in digital divide and fulfils the universal connectivity objective (Nozdrin, 2021). Furthermore, in some parts of North America such as Canada, NPOs are playing a crucial role in providing broadband connectivity to smaller communities (Nozdrin, 2021). These NPOs are also subsidized by the government.

In the developing countries such as India, there is new entrant which surfaced as a low-cost operator that is enhancing universal access. This late entrant has become a threat to the existing incumbents (Lewis, 2020). It is assumed that this late entrant gained access into the telecommunications market due to flexible RF spectrum assignment models used by the regulator TRAI to allow reserve RF spectrum for new entrants in the telecommunications industry (Nir and Nikhilesh, 2017)

In the Latin American region, Chile has employed a beauty contest approach for allocating RF spectrum. This model has been notably effective in Chile, leading to the allocation of frequency bands such as 850 MHz for 2G services, along with 700 MHz and 2.6 GHz. As a result, Chile has emerged as a frontrunner in the expansion of mobile networks in Latin America, achieving a network readiness score of 4.6 points.

As indicated earlier, one of the biggest challenges faced by South Africa's telecommunications industry is caused by the usage of the auction RF spectrum allocation model. This is because the model has been criticized to be benefiting a few incumbent operators at the expense of new entrants (Song, 2017). The allocation of RF spectrum models has also presented various challenges in the telecommunications industry to some African countries such as Nigeria and Senegal.

### 2.5. Africa Analysis

The African telecommunications sector is managed by the ATU which aims to ensure sustainable telecommunications businesses, effective use of RF spectrum, mobile broadband services to a wider population in African countries, facilitation of social economic benefits, and nation's economic developments (Hazlett, 2018).

Nigeria, through the Nigerian Communications Commission (NCC), provides a valuable lesson in developing a framework to guide RF spectrum sharing and trading. The NCC commenced this process in 2017, engaging stakeholders through a comprehensive public consultation that concluded in 2018 with the publication of the finalized RF spectrum trading guidelines (Pogorel, 2017). However, prior experiences from several countries indicate that many spectrum auctions have been challenging, leading to unsuccessful outcomes due to high reserve prices and limited available spectrum (Lewis, 2020).

A balance was achieved in Nigeria by employing auction licensing model that allocated RF spectrum to operators who could utilize it more effectively (NCC, 2019). Nigeria's regulatory agency, the Nigerian Communications Commission (NCC), conducted multiple RF spectrum auctions to regulate and manage the RF spectrum. These auctions included the digital mobile auction of the 900MHz and 800MHz bands (2001), 2GHz third generation (3G) wireless mobile telecommunications technology auction (2006), 2.3GHz wholesale wireless access auction (2014), and 2.6GHz RF spectrum auction (2016) (Song, 2017). Furthermore, in 2016, the NCC auctioned two 27MHz slots solely for Lagos State shortly before the 2.6GHzauction took place.

This success was also accompanied by some failures in Nigeria some new entrants struggled to make effective use of the assigned RF spectrum. The NCC's more recent 2015 auction of 30 MHz of RF spectrumwas less than successful (Lewis, 2020). It attracted only two bidders, with a wholesale wireless access license being granted to a new entrant for US$23 million (Pogorel, 2017). Although it was lauded as a success in bringing a new market entrant into the field of Long-Term Evolution (LTE) services, the new entrant has struggled to break into the market (Song, 2017).

In Senegal, the auction of RF spectrum licenses since 2016 has been mired by controversy and allegationsof an unfair process that favored two dominant incumbent operators, causing a boycott by some frustrated operators (Song, 2017). The award criteria and decision-making process were claimed to have been questionable, leading to accusations of preferential treatment and lack of transparency. These issues highlight the challenges that regulators face in generating competitive and fair outcomes through RF spectrum auctions in situations where a small number of incumbents enjoy immense market power (TeleGeography, 2016).

### 2.6. South Africa's Analysis

In SA, the telecommunications industry is dominated by the electronic communications network service (ECNS) licensees, responsible for rollout of telecommunications services. These ECNS are the existing major five operators within the country (ICASA, 2019). Small operators and new entrants find it difficult to penetrate the telecommunications space in this country due to current policies by the regulator and anti-competitive behavior by some of the incumbent operators (Venkatram and Zhu, 2012). The used RF spectrum assignment model which in most cases is through auction is perceived as a failure to promote equitable assignment to operators that are dominant in the market (Lewis, 2020). This has resulted in strong criticism against ICASA for not considering other small operators when it comes to RF spectrum licensing(Foster, 2018).

Moreover, SA's governance of broadcasting, broadcasting signal distribution, and telecommunications is governed by the Electronic Communications Act 36 of 2005. The Act's objective is to promote sectoral convergence and provide legal framework for it (ICASA, 2006). The Act underwent amendments in 2014 aligning it with empowerment legislation, refining licensing provisions, removing regulatory impediments, and requiring the Minister of Communications to establish a policy advisory council on broadband (ICASA, 2016). These changes aim to promote effective competition between licensees.

In 2018, the government made another attempt to amend this Act with the intention to promote competitive market-based auctions of RF spectrum and allowing the new entrants to participate and benefit from the RFspectrum assignments (Research ICT Africa, 2020). However, it is alleged that this amendment Bill was cancelled in February 2019 due to further consultations that needed to take place in relation to the Fourth Industrial Revolution (4IR) and this gave the greenlight to the normal auction process to proceed, which ended up benefitting the incumbent operators (Lewis, 2020)

## 3. METHODS

This study employed a qualitative desktop research method, consisting of the following key aspects:

- Defining the research aim and identifying key concepts
- Conducting a literature search using keywords
- Collecting and organizing data from sources
- Analyzing data using qualitative tools such as content analysis
- Drawing conclusions based on findings and formulating recommendations

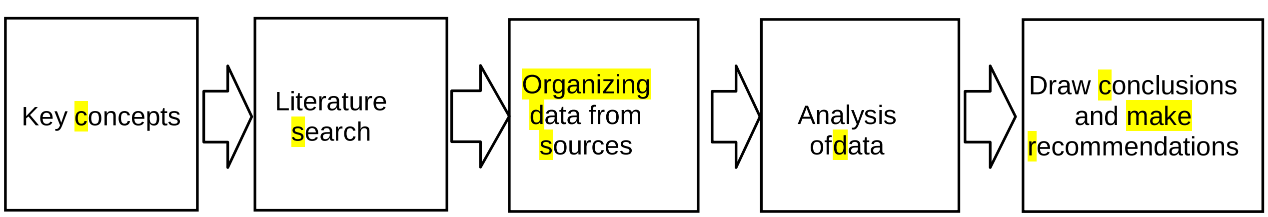


**Fig. 2:** A qualitative desktop research approach, adapted from Liu and Sun (2017)

A qualitative desktop research approach was utilized to analyze publicly available information on RF spectrum allocation models with the aim to identify the gaps in SA. The authors have used preliminary literature analysis for this study looking at the key concepts underpinning the research area and the main sources and types of evidence available (Harrtis, 2011). During the preliminary analysis of the literature, the authors identified challenges pertaining to RF spectrum allocation models, universal coverage, and affordable connectivity. They conducted a preliminary review process to explore challenges related to existing RF spectrum and allocation models, utilizing keywords such as "RF spectrum", “RF spectrum assignment” and "RF spectrum allocation" along with boolean operators like "AND," "OR" and "NOT." Thus, the objective of the qualitative desktop approach in this paper was to conduct an exploratory examination of the literature pertaining to RF spectrum allocation models.

## 4. RESULTS AND DISCUSSIONS

### 4.1. Results

The results from the literature reveal that there is a gap associated with the existing RF spectrum assignment models in achieving the inclusive and equitable allocation. The potential gaps are based on the policy regulations on existing RF spectrum allocations, competitive fairness of allocation models, alternative RF spectrum assignment models and regulators leverage on the high-demand RF spectrum to benefit new entrants. The Table 1 below highlights the summary of the findings based on the common models that are used for allocation of RF spectrum.

**Table 1: Summary of the RF spectrum allocation models**

| Model | Characteristics |
|---|---|
| Beauty Contest | • Time consuming<br>• Less used model<br>• Characterized by red tape |
| Lottery | • Quicker allocation process<br>• Lack technical abilities<br>• Less used model |
| First Come First Serve | • Less utilized model<br>• Time efficient<br>• Lacks technical abilities |
| Auctions | • Mostly used and favored<br>• Time efficient<br>• Demand vs supply<br>• Profit maximization<br>• Less competitive<br>• Limit new entrants into the market<br>• Steep price reserves |

The above Table 1 outlines the RF spectrum allocation models and their description. These models influence the policy and how the allocation of RF spectrum should be conducted by the regulator. A detailed discussion will follow in the discussion of the results section. As an extension to table 1, Table 2 below provides the results in terms of how these models influence the policy, by identifying the gaps associated with the existing models.

**Table 2: Policy gaps associated with spectrum allocation models.**

| Potential Gap | Description |
|---|---|
| Promote competition | Promote a competitive market-based policy for RF spectrum and allowing the new entrants to participate and benefit from the spectrum assignments. |
| Equitable assignment model | Accommodating new entrants, low-cost operators, and incumbent operators through an understanding of the country's economic needs. |
| Spectrum reserve | Reserving spectrum for new entrants. |
| Low-cost connectivity | Policy to make provisions for low-cost connectivity. |

The Table 2 outlines the summary of results for potential gaps associated with spectrum allocations at a policy regulation level. These gaps were identified from the literature using a qualitative desktop research approach. They are deemed to have impact on the policy consideration pertaining to spectrum allocation. To this end, it is important to emphasize that these findings will be analyzed in relation to SA's spectrum allocation laws, regulations, and policies as future research. These results are discussed in detail below.

### 4.2. Discussions

The discussion of the results is based on Tables 1 and 2. These findings are based on a desktop study of secondary data analyzed during the literature review exercise. The results from Table 1 provided a summaryof the existing RF spectrum allocation models (beauty contest, lottery, first come-first serve and auctions) based on their application by various countries. As a result of the analysis, auctions are widely utilized as a RF spectrum allocation model of choice. This model is preferred because it maximizes profit by taking advantage of RF spectrum demands, is less time-consuming and has a great economic return for a country. In various countries, auctions are recommended for good practice and time efficiency (Janali, 2015; Foster, 2017). However, there is a major criticism associated with auctions as they are described as the model thatis less competitive and likely to benefit the incumbent operators whilst limiting the market penetration by new entrants. This is due to the high price reserves and the failure to accommodate the small operators.

Literature supports the findings that the auction model of RF spectrum allocation is unfair, as operators with financial capacity and the maximum value of RF spectrum use are likely to bid during the allocation process. Their financial situation will allow them to win the auction, leaving smaller operators with less spectrum and fewer opportunities (Sutherland, 201; Mulas, 2019). Additionally, some studies are advocating for policy and regulatory measures to address the auction model in a way that benefits both new and established operators (Tadjadine, 2021; GSMA, 2021; Foster, 2018).

There are other RF spectrum allocation models, such as beauty contests, lottery and first come first serve as indicated in Table 1. However, these models are less commonly used by most countries due to their severe limitations in comparison to the auctions model. A comparison of the lottery with the first come- first-serve model results reveals some similarities. While these models are time-efficient, they lack technical and tactical capabilities for allocation. Some researchers criticize these criteria for their excessive inefficiencies and tendency to enable RF spectrum allocation to operators who do not necessarily have the technical capabilities (Hazlett, 2018; ITU, 2019; GSMA, 2017). Furthermore, the beauty contest appears to be one of the least used models due to its shortcomings. Results also reveal that this model is not preferred due to its nature of implementation. The implementation process is prone to bureaucracy and maysometimes lack precision. The literature is backed by the argument that the criteria is characterized by the complicated administrative procedures.

Governments tend not to do a thorough due diligence when allocating the RF spectrum. This results in a RF spectrum becoming an un-used resource, sometimes, due to a lack of operator technical competency (Mulas, 2019). In conclusion, the shared characteristic among these four RF spectrum allocation models is their policy inadequacies. They do not effectively tackle the issue of universal connectivity and the integration of new market participants. The results in Table 2 revealed that gaps in spectrum allocations have influence on policy formulation. Findings from the literature have identified some of the gaps, including:

- Lack of tactics to promote competition,
- Equitable assignment model to accommodate new entrants and existing operators,
- Policy to accommodate low-cost connectivity framework, and
- RF spectrum reserves for the new entrants.

In the literature, a detailed analysis of the policy shortfalls has been presented, and numerous studies suggest policy reforms to address the gaps identified. On the issue of the policy to address the competition gap, studies are debating that the policy must promote a competitive market-based RF spectrum policy that willallow the new entrants to participate and benefit from the spectrum assignments (Lewis, 2020; Research ICT Africa, 2020; Venkatram and Zhu, 2012). To promote competition, the same authors have suggested equitable spectrum assignments. By understanding the country's economic needs, they argue that this proposal accommodates new entrants and incumbent operators. Thus, a competitive market-based policy can be a solution and it has been assessed by some countries such as the United Kingdom, Denmark, and Germany (Nozdrin, 2021).

## 5. CONCLUSIONS

This study investigated and provided an analysis of the existing RF spectrum allocation models in South Africa. Allocation policies and models vary by country, based on their telecommunications vision and strategies. The findings revealed that auctions are the most adopted models for RF spectrum allocation which is utilized by the regulator (country) to maximize profits for RF spectrum licensing. This model hasbeen characterized as a model that benefits incumbent operators by enhancing their broadband footprint and capacity. However, literature shows that the auction model has many drawbacks, which some of them exclude new entrants from participating in the allocations.

The study has shown that RF spectrum allocation models have gaps. The findings reveal that countries have reformed their policies to accommodate both incumbent and new entrants. This is done by crafting a policythat reserves RF spectrum for various categories and landscape. In this way, new entrants and incumbent operators can benefit from RF spectrum allocations, bridging the existing gap. Further to this, the policy identified by other countries such as Canada, has differentiated the RF spectrum allocations based on the country analysis of telecommunications. This is intended to improve broadband connectivity. This can be a lesson for other countries to use this as a case study to reform their RF spectrum allocation policy. This will enable them to be more equitable and inclusive in nature. To accommodate a wide range of telecommunications operators, future research should be conducted to analyze the findings in relation to South Africa’s RF spectrum allocation laws, regulations and policies and propose an alternative and inclusive framework.

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