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**SATRC REPORT ON**

**ASSESSMENT OF CURRENT PRACTICES IN SPECTRUM MANAGEMENT AND DEVELOPING SPECTRUM ROADMAP**

**Prepared by**

**SATRC Working Group on Spectrum**

Adopted by

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# **EXECUTIVE SUMMARY**

Wireless technology is evolving rapidly in such a way that consumers and businesses have access to new wireless technologies and new services are being introduced as per time and technology demands. In order to plan and implement best wireless technology adoption, SATRC countries have put in place several spectrum management practices and strategies. However, this is becoming more challenging due to the pace of development in technology and services. In addition, the implementation of spectrum management framework and allocation often take a considerable amount of time to take effect.

 A spectrum roadmap is essential to ensure there is enough spectrum to meet surging demand for mobile services. Development of Spectrum Roadmap is required to SATRC members to forecast the future and increase certainty about the regulator’s future allocation plans and spectrum management. Therefore, it is imperative to assess the current spectrum management practices in SATRC countries and review it for further improvement by developing a spectrum Roadmap.

This study assesses current practices of spectrum management framework in SATRC countries. The study included an analysis of spectrum allocation, spectrum assignment procedures, spectrum pricing, spectrum monitoring, international frequency coordination, spectrum engineering, spectrum refarming, organizational framework, etc. in SATRC countries. The study shall also highlighted the need of a spectrum roadmap to meet surging demand of mobile services and to forecast future spectrum allocation plans for spectrum management in the SATRC region.

# **1. Introduction**

The radio frequency spectrum is a natural, finite, non-depleting and valuable national resource essential for radio communication. It is a subset of the electromagnetic waves lying between the frequencies from 9 kilohertz (kHz - thousands of cycles per second) to 30 gigahertz (GHz - billions of cycles per second), as shown in Fig. 1. These radio frequency bands support a wide range of business, personal, industrial, scientific, medical research and cultural activities, both public and private.



*Figure 1: Radio spectrum (Source: ICT Regulation Toolkit)*

For existing and evolving technologies and applications, appropriate and sufficient spectrum has to be assigned, to ensure technical and economic efficiency. To meet the surging demand of wireless technologies in terms of user experience and service quality, proper and prior planning is necessary. As the pace of new technology evolution is increasing, a responsive spectrum management and planning framework is required that allows the operators timely relocation of the spectrum, planning, and implementation. Such a framework, also called the spectrum roadmap, is an evolving document that undergoes continuous reviews and updates.

The process of developing national spectrum roadmap cannot be isolated from the current spectrum management practices. The SATRC countries, themselves, are practicing various policies and strategies for spectrum management. A considerable amount of administrative delay is being noticed in some of those countries while incorporating new technologies and corresponding frequencies to national policies. Therefore, assessment and review of current spectrum management practices in SATRC countries is crucial for formulating an organized spectrum roadmap. A spectrum roadmap that is harmonized among the SATRC members helps the regulators not only in national spectrum management, but also in regional coordination and collaboration.

# **2. Spectrum Management**

Radio spectrum is a scarce/finite resource in terms of instant capacity, inexhaustible when used over time, but can be in short supply in areas of high demand. The scarcity of frequency spectrum is illustrated by more and more wireless applications competing to access spectrum and also by the increased demand for higher data rate or greater coverage. Even if the improvement of current technologies contributes to a more efficient use of the spectrum, increased demand requires that spectrum be used reasonably and that effective spectrum management processes be implemented.

Radio Frequency Spectrum needs to be used efficiently by qualified and licensed users. The radio frequency bands are of such nature that frequency bands can be utilized at same point, in same time, almost once while there could be more than one demand for utilizations. Uncoordinated electromagnetic radiation of individual and independent spectrum users could interfere with each other. Spectrum management is the administration of radiocommunication sector, monitoring of spectrum utilization, regulation of market, implementation of strategies, case studies and development of sector policy national regulator.

Effective use of spectrum can make a big difference to a country’s prosperity, especially where communications are heavily reliant upon wireless technologies such as mobile phones. Spectrum scarcity can have an adverse impact upon prosperity. The demand for spectrum is increasing and many frequency bands are becoming more congested especially in densely populated urban centers. Spectrum managers are taking various approaches to improve efficiency.

Spectrum management is a combination of administrative and technical activities for efficient utilization of spectrum by users without causing harmful interference in their service area. It is the art and science of regulating the use of the radio frequencies to enable the optimum number and types of services to coexist in the same physical space. Spectrum is regulated by the state for coordination of radio emissions so as to avoid radio interference and allocation of scarce resources between competing uses. Acts, Laws, Regulations, Procedures and organization are developed by National Administrations to carry out the duties of spectrum management within its territory. Meanwhile, national regulations of a nation must comply with the Radio Regulations of the International Telecommunication Union to ensure globally harmonized allocation and usage of the spectrum.

The ability of each country to take full advantage of the spectrum resource depends heavily on spectrum management activities. Effective management of the radio spectrum is required to ensure spectrum access for new services and technologies, growth in existing services and avoidance of interference between users. The spectrum management system must provide an orderly method for allocating and assigning frequency bands, authorizing and recording frequency assignments and establishing regulations and standards. The effectiveness of a spectrum management is related to how well the system meets the national needs and how well it is able to safeguard the interests of the public. Although no two administrations would manage the spectrum in exactly the same manner, the basic processes are essential to all.

## **2.1 Objectives of Spectrum Management**

Spectrum has to be managed to ensure its rational, equitable, efficient and economical use by all radio communication services and users, taking into account that interference is caused between radio communications systems unless sufficient isolation from each other is provided: in frequency, distance or time domains; radio spectrum is a finite resource in terms of instant capacity, although it is inexhaustible when used over time; new and new applications mean ever growing demand for new spectrum access opportunities. For physical/technical reasons, some parts of the spectrum have greater demand, e.g. VHF/UHF bands due to better propagation conditions; there is a need to ensure equitable distribution of spectrum – between operators within a country and between countries; there is a need to ensure spectrum use is well coordinated between various users within the same and neighboring countries[[1]](#footnote-1). Moreover generic objectives of spectrum management may include:

* Allocation of the spectrum for government, industrial and commercial sectors and ensuring spectrum availability for vital public services such as safety and security services.
* Improving the efficient and optimal use of the spectrum resource through adoption of advanced spectrum allocation, management techniques and licensing processes based on operational requirements and technical as well as economic viability.
* Making telecommunications services affordable and reliable for personal and business use.
* Prevention and elimination of interference and safeguard of life and properties.
* Maintaining and developing effective competition.
* Ensuring flexibility and adaptability and ease of access to the spectrum resource in response to technological advances, and economic, social and market factors.
* Planning for future needs and management and monitoring the utilization of the spectrum resource in accordance with legislative and public policy objectives and international agreements.
* Promoting innovation, research and development of new radio communication-based techniques/ services/ applications as well as supporting dissemination of educational, general and public information and entertainment.
* Coordinating and establishing well balanced national spectrum and radio communication policies and plans by widely consulting with all interested parties and the general public.
* Protecting national interests while striving for global harmonization of spectrum along with coordinated spectrum policies and utilization working with regional and international organizations and in compliance with treaty obligations, including those of the ITU.
* Promoting the reduction of digital divide.

In the context of national spectrum management, the primary objectives may be:

* **Interference Management:** Take necessary actions to avoid interference between radio systems.
* **International obligations:** To meet the international obligations set by ITU Acts and Radio Regulations.
* **Demand satisfaction:** To satisfy the demand for access to the radio spectrum by all kinds of users.
* **Rational distribution:** To ensure rational distribution of spectrum to support safety, social, economic, security and defense requirements, according to national policies.
* **Creating an enabling environment:** To protect existing services, while enabling the introduction of new services and technologies.



*Figure 2: National Spectrum Management System (Source: ITU)*

The major function of national spectrum management is shown in the Fig. 2 and in general, the national regulator has major responsibility for it. Major functions of the national regulatory authorities may include developing spectrum management policy and planning of spectrum, frequency assignment and licensing, standardization and type approval of the radio equipment, enforcement and monitoring, international cooperation, liaison and consultation with stakeholders, and administrative and legal support. The effective management of the spectrum resource depends on a number of fundamental elements. In the contest of national spectrum management, the most important thing that needs to be taken into account is that no two administrations are likely to manage the spectrum in exactly the same manner, and the relative importance of these fundamental elements may be dependent on an administration’s use of the spectrum, they are essential to all approaches.

## **2.2 Key aspects of Spectrum Management**

To understand the different aspects of spectrum management, let’s consider the most generic aspect i.e. societal aspect of regulation. For instance, assume that there is a policy such as road traffic regulations, its artifacts may be road making, speed signs, etc. and that come into the practice as policy enforcement. Similarly, in the context of national SM the societal aspects may as shown in Fig. 3.

Policy

Artefacts

Practice

*Telecoms Law, NFAT, rules*

*NRA*

*Licence*

*Individual*

*General*

*Monitoring*

*Enforcement*

*Radio*

*Market*

*Figure 3: Societal aspects of national spectrum management (Source: ITU, Dr. Arturas Medeisis)*

Another most important aspect of spectrum management is the economic aspect. The increasing use of new technologies has produced tremendous opportunities for socio-economic development of the country and the ongoing technological developments have opened the door to a variety of new spectrum applications. Indeed, the ICT development is heavily dependent on the spectrum and the spectrum fee and ultimately the national GDP is highly related to the ICT development. In the context of a developing country the direct contribution of ICT development on GDP is even higher. Moreover, the spectrum fee is also one of the major sources for a country. In this context, spectrum management has a direct and significant impact on the socio-economic development of the nation. Moreover, the different aspects of spectrum management are further discussed in the following.

### **2.3.1 Planning and policy-making**

Planning is of fundamental importance in spectrum management. Plans and organizational structure of the administration are devised to achieve the objectives of national spectrum management. The plan comprises measures to be taken to achieve the objectives and goals determined by the state for optimum occupancy and effective utilization of the spectrum. Planning should take into account factors such as major spectrum shifts, emerging technologies, new services for which there are no current allocations, projected crowding in specific bands etc.

Development of policies, rules and regulations is also crucial in spectrum planning. Inputs from local and national government, industries and all relevant stakeholders should be considered while formulating the plans and policies. Implementation of these legislations provides a framework for releasing frequency by considering the technology evolution and spectrum demand of present and future. The output of the policy-making process is the allocation of frequency bands to the various radio services and applications. When there are competing interests for spectrum use, the administration should choose the services that best serve the public and government interest.

**2.3.2 National Frequency Allocation Plan (NFAP)**

Allocation (of a frequency band) is the entry of a given frequency band in the Table of Frequency Allocations for the purpose of its use by one or more terrestrial or space radio communication services or the radio astronomy service under specified conditions. The NFAP consists of current assignments and future plans regarding spectrum usage. It should be aligned with the Regional ITU Allocation Table to ensure harmonized use of spectrum in the region, minimal cross-border interference, and matured ecosystem resulting in low cost of network as well as user equipment.

The frequency allocation plan determines how bands will be used, how radio services will be implemented, which technologies will be accepted or if the prevailing technologies will be decided by the market alone.

### **2.3.3 Assignment and licensing**

Assignment (of a radio frequency or radio frequency channel) is the authorization given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions. Assigning frequency and authorizing the use of the same in various services and applications is the principal and regular task that a spectrum management organization performs. The common spectrum assignment objectives are:

* Promoting the efficient use of spectrum
* Supporting mobile service competition
* Ensuring service continuity for end-users
* Adopting a well-run, timely and legally robust process
* Potentially other policy goals such as achieving wide coverage
* In some cases, generating revenue to government

Auctions are a proven means of assigning spectrum but poor auction design can lead to spectrum being awarded inefficiently or in a way that undermines competition. In some circumstances, administrative assignments can offer advantages over auctions. However, the implementation process of the approach is more important rather than the approach itself.

Spectrum awarded on technology neutrality basis ensures efficient use of the radio frequency and maximizes benefits of the radio services and applications. Spectrum tied with declining technologies and high fees for upgrading the technologies can hinder the technological development and associated benefits.

License duration and renewal procedures are also crucial for long-term investment in radio networks. Long initial period and presumption of renewal can facilitate introduction of new services and continuity of the service provider to end users.

### **2.3.4 Spectrum monitoring and enforcement**

Spectrum monitoring supports the overall spectrum management process in general, by providing the actual use by practical measurements of channel and band usage. From inspection and monitoring, channel availability statistics may be derived, and the effectiveness of spectrum use can be assessed. Spectrum monitoring can be viewed as a validation check on the spectrum planning activity, confirming that existing planning policies are actually working in practice and if not, provide advice for improvement. Monitoring activities help the spectrum managers to identify and measure the interfering signals, detect and locate illegal radio devices, observe and measure the actual usage of assigned frequencies etc. Monitoring can also identify the need for refarming, infringements of license conditions, future spectrum requirements etc.

Authorizing the use of the spectrum does not automatically ensure that the spectrum is used as intended. Due to various reasons such as complexity of the equipment, interaction with other equipment, malfunction of equipment, or deliberate misuse, spectrum assignment does not automatically ensure that the spectrum is used as intended. The monitoring system provides a method of verification on the spectrum management process.

Administrations which perform both spectrum management and spectrum monitoring should consider using an integrated, automated system with a common relational database. This integration allows exchange of information between the management and monitoring databases, tasking of the monitoring system by the management system, and reporting of monitoring results to the management system, and other useful features such as remote access to system resources.

The information obtained from monitoring can be used to trigger subsequent enforcement of relevant regulations. Actions can vary from verbal and written warnings to more severe sanctions such as monetary fines, confiscation of offending equipment or license revocation, depending on the severity of the infringement and the level of cooperation of the offending user.

### **2.3.5 Spectrum Pricing and Socio-economic aspects**

As the frequency spectrum is a scarce resource owned by the State, the State has the right to require occupants thereof to pay spectrum fees. Similarly, the State or the regulator can collect administrative fees to fund the activities related to planning, management and monitoring of the spectrum. While the sole purpose of administrative fees should be to pay for the service rendered by the authorities, the spectrum fee is collected considering socio-economic status of the country as well as all the benefits that occupant derives from the spectrum and it represents financial resources for the State. The establishment of spectrum fees and administrative fees must be carried out with transparency, objectivity, proportionality and non-discrimination. In return for the fees they pay, users of assigned or allocated frequencies enjoy protection under the relevant provisions of the regulations in force. The broad goals and objectives associated with spectrum pricing are:

* Covering the costs of spectrum management activity borne by the spectrum management authority or regulators.
* Ensuring the efficient use of the spectrum management resource by ensuring sufficient incentives are in place.
* Maximizing the economic benefits to the country obtained from use of the spectrum resource.
* Ensuring that users benefiting from the use of the spectrum resource pay for the cost of using spectrum.
* Providing revenue to the government or to the spectrum regulator.

For the purpose of pricing, spectrum valuation is required. Spectrum is either valued using prices in market transactions (auctions, spectrum trading or leasing) or by administrative means.

*Market-based economic value:*

Market based methods allow users to estimate the commercial value of spectrum based on their own and the market's expectations around what benefits that can be derived from its use. Participants in a competitive auction or engaged in a spectrum trade will determine the price at which spectrum rights will be obtained by license from the regulator or transferred between parties. When spectrum prices are determined through market mechanisms, price levels at a given time may be influenced by a number of factors such as geography, competition amongst potential users, advances in technology, the present value of cash flows derived from a particular service over time, the general economic climate, and particular conditions and obligations to licensees

* In an auction, the economic value is reflected in the price paid by the successful bidder, which will meet or exceed the reserve price established for the auction. It will be composed of bidding deposits paid at the outset and the applicable winning price.
* In the case of spectrum trading, the economic value is reflected in spectrum trading prices and the spectrum fee will include any transaction costs imposed on the participants in the trade.

*Administrative pricing:*

Administrative methods are also used in the assignment of spectrum and the determination its prices. In some cases, the method employed simply results in a recovery of spectrum management costs plus opportunity cost of the spectrum (administered incentive pricing). In this method, prices are set at a level to encourage efficient use and that reflect spectrum scarcity. In other cases, analytical and modeling techniques are used develop prices which reflect the underlying spectrum value and corresponding spectrum usage fees. Most regulators establish rules based on coverage, occupied bandwidth, service type, covered region type, daily usage time, user type, yearly usage duration etc. to determined the actual sum to be paid by the spectrum user.

The spectrum fee collected not only contributes significantly to the national GDP, properly managed radio frequency promotes overall economic growth by influencing employment opportunities directly or indirectly. Some uses of the radio spectrum generate economic benefits but do not directly generate revenues. The economic benefits that the use of spectrum generates in such activities however are not readily apparent. Examples of services providing social benefits include broadcasting (providing education, training, news and recreation etc.), emergency services (accident and rescue services including disaster control facilities, contacting police etc.), – personal services (home health care/nursing, home security for the elderly) and research (meteorology, radio astronomy etc.) etc.

### **2.3.6 International and regional coordination and cooperation**

Radio communications have a significance that goes beyond the borders of each nation. Effective spectrum management, therefore, requires coordination and cooperation between country administrations and international organizations. Exchange of information with other administrations as well as notification to the Radio communication Bureau (BR) helps in harmonizing radio-frequency allocation across borders and reduces cross-border interferences. In this regard, regularly updating the international (MIFR, Master International Frequency Register) and regional (AFIS, APT Frequency Information System) database with the national frequency assignment data is an important activity.

International coordination is mandatory for systems such as navigation, and satellite as these services are not confined to the national boundary. Multinational cooperation has added benefits as it helps to make the telecommunication service affordable and reliable. Use of globally or regionally harmonized spectrum creates a larger common market to the manufacturer of the devices, and causes to reduce the price of user and network equipment.

International trends can be crucial for planning the future of spectrum management. These trends can be identified through professional literature, through direct consultation with businesses or government representatives of other countries or through participation in bilateral, regional (APT) and international (ITU) conferences and meetings. Though not directly responsible for the rules and regulations for spectrum use, many other organizations, such as the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), the World Meteorological Organization (WMO), the Special Committee of the International Electrotechnical Commission for Interference (CISPR), negotiate the agreements and standards that impact spectrum use. Therefore, administrations must also consider participating in these organizations.

## **2.4 Changing context and its impact on spectrum management**

In the field of telecommunications, innovation pace in technology and services is high and demarcation between different services and technology is becoming absolute. Some of the major innovations that require the review of existing spectrum management principles are discussed in the following subsections.

Instead of distinct networks and platforms and limited and distinct services, numerous legislations and policies, today there is increasing demand for wireless broadband services, digital convergence, data rate intensive multimedia services such as AR/VR and video streaming, many applications, and need for the convergence of the regulation. More specifically, new technologies and services, such as Video on Demand and IPTV, create the challenging scenario for the traditional regulation where broadcasting regulation and telecommunication regulation is separate, and this situation is still in practice in developing nations.

In the near future, due to the rapid development in ICT technology, the internet will be embedded in everything and everywhere, wireless will be everything, software defined network, Fintech, Artificial Intelligence, Blockchain, horizontal and vertical integration, etc. are going to be the major dominant services. The rapid development in the ecosystem is making consumers more ambitious for more services, including seamless connectivity, device diversity, broadband enabled apps, high speed, more bandwidth, low latency, social media, and converged services. Meanwhile, operators are seeking higher return on investment, certainty, service neutrality, technology neutrality, timely release of spectrum, availability of prime spectrum, wider contiguous spectrum, and immediate assignment and allocation. Therefore, regulators are also facing challenges from new dimensions such as public interest, public safety and security, licensing/authorization regime, reasonable pricing, proactive, enabling, adoption of new technology, quality of experience, rights, timely decision, innovation and adaptability.

To approach the issues the spectrum management needs to precede steadily but cautiously, the market-based approaches may not be universal panacea, different services submit differently to the various spectrum assignment mechanisms. Some of the innovative spectrum management techniques required to overcome the challenges put by evolving context is described below.

### **2.4.1 Spectrum for license-exempt operations**

License-exempt spectrum has become a critical part of mobile connectivity as it provides people an additional method of accessing voice and data communication services on their handheld and other wireless communication devices. Because of the significant growth of wireless devices and applications, the license-exempt spectrum has witnessed a significant increase in use and innovation in recent years. Furthermore, the majority of IoT devices when the IoT industry grows are expected to use license-exempt spectrum to communicate with computers, smartphones and tablets, as well as to communicate amongst themselves (e.g. M2M). Increasing demand for higher throughput of Wi-Fi services and probable high volume of IoT devices are likely to put pressure on existing license-exempt bands soon[[2]](#footnote-2). Therefore, the spectrum management authority may need to identify additional license-exempt bands.

### **2.4.2 Spectrum Sharing**

The global success of mobile services has been built on a foundation of exclusively licensed spectrum as it supports widespread services and the certainty needed for long-term heavy network investment and high-quality service. The continued rise in data traffic due to Smartphone, internet of things, military and public safety radios, wearable devices, smart vehicles and countless other devices means mobile services rely on access to growing amounts of spectrum to meet demand. However, it is increasingly difficult to completely clear new frequency bands for future mobile use. Spectrum sharing may be a way to help, when clearing a band is not possible, by enabling mobile access to additional bands in areas, and at times, when other services are not using them.

With the maturity of 4G ecosystem and emergence of 5G, ability of sharing of spectrum resources between those two technologies is essential for better quality of experience. Dynamic Spectrum Sharing (DSS) is a technology that allows the deployment of both 4G LTE (Long Term Evolution) and 5G NR (New Radio) in the same frequency band and dynamically allocates spectrum resources between the two technologies based on user demand[[3]](#footnote-3). With DSS, an operator doesn’t have to split the available spectrum or have a dedicated spectrum for either 4G LTE or 5G. Instead, they can share the whole frequency band between the two technologies.

Dynamic spectrum access is an advanced approach of spectrum sharing that allows users to access a particular piece of spectrum for a defined time period or in a defined area which they cannot exceed without re-applying for the resource. It permits communications to work by monitoring to detect unused frequencies, agreeing with similar devices on which frequencies will be used, monitoring frequency use by others, and changing frequency bands and adjusting power as needed[[4]](#footnote-4).

It is essential that regulators think carefully about which bands suit sharing in terms of capacity and select the right sharing framework to ensure innovative and affordable mobile services can be supported. As sharing can play a role in the 5G era, the regulator should encourage operators for sharing their spectrum to support faster services, improve coverage and drive innovation[[5]](#footnote-5).

The spectrum sharing agreements between operators can be through commercial agreements for coordinated simultaneous use (concurrent shared access) or by awarding rights to use spectrum in areas and/ or at times when the incumbent is not using it (licensed shared access). In either case, the regulator needs to be more careful not only to make sure that the agreement between operators is reasonable, but to avoid probable interference between different networks using the same frequency as well.

### **2.4.3 Spectrum Trading**

With innovation being a distinctive feature of the radio communications, it is desirable to have ready access to suitable frequency bands more regularly available. Spectrum trading is the process that allows the transfer of certain rights to use radio frequency spectrum from one undertaking to another. Smooth trading mechanisms enable the flow of spectrum resources among users and can contribute to providing speedier access to spectrum, compared to traditional administrative methods. Spectrum trading makes it easier for prospective new market entrants to acquire spectrum and develop their business, it enables fast-growing companies to expand more quickly than would otherwise be the case, and it can provide considerable incentives for incumbents to invest in new technology in order to ward off the threat of new entrants[[6]](#footnote-6).

Mainly, there are two types of spectrum transaction. In spectrum leasing, spectrum may be accessed by a spectrum user for a specified period under a contract with an existing licensee. In this approach, the spectrum license remains with the existing licensee, while the usage rights are transferred to the new party via contract. In spectrum transfer, the ownership of the spectrum (license) is transferred to the new user including license rights and obligations.

Spectrum trading is viewed as the key step in the spectrum management regulatory reform, capable of unlocking the potential of new technologies and of eliminating artificial scarcities of spectrum which find expression in inflated prices for spectrum using services. It improves upon the efficiency and economy of assigning spectrum through administrative means and is more responsive to fluctuating and changing spectrum needs and uses over time[[7]](#footnote-7).

A secondary market of spectrum is possible only when the regulatory administration provides the licensee with both transferable spectrum rights and a license with adequate security of tenure and duration to operate. Any transfer of rights needs to be registered with the spectrum management authorities in a sort of ‘frequency and owner register’ and like any other market, an ‘antitrust authority’ is needed to ensure fair competition and avoid dominant market power.

## **2.5 Assessing the spectrum management needs and best practices**

First and most important step for spectrum management is the legal framework for policy formulation and its implementation. The international, regional and national regulatory frameworks also significantly influence the spectrum policy formulation, harmonization and implementation. Indeed, the ITU harmonizes the efficient use of the spectrum resource on a global basis on behalf of governments and ultimately, the implementation – how and when recommendations and regulations are implemented – rests with national governments. One of the hurdles in establishing coordinated policy at the national level is a diverse regulatory framework for broadcast and telecommunications i.e. in some cases, there is one regulator for both broadcast and telecommunications and in other cases, the regulation of these services is divided between separate regulators.

To deal with the issues arisen with the convergence in technology and services. As shown in Fig. 4, today there are more than 158 separate telecom/ICT regulators worldwide and over the past few years, a growing number of telecom/ICT regulators have seen their mandates expand to include information technology and broadcasting. More recently, electronic content, cyber security, data protection, privacy and environmental matters have been added and in recent days number and the concept of converged regulation is further increased.



*Figure 4: Mandate of regulators, worldwide, 2011 (Source: ITU World Telecommunications/ICT regulatory database)*

The spectrum management policy needs to develop and approve, after extensive and meaningful stakeholder input and consultations. It governs spectrum's use, its licensing, spectrum prices, and reframing. Indeed, the good policies are essential for better decisions to be made more quickly, thereby reducing the risk of regulatory and market failure. Spectrum policies include pronouncements on regulatory direction for the following:

* Spectrum planning policies including the study and assessment of spectrum demand and supply for government and non-government uses, and requirements for band plans;
* Spectrum authorization policies including the use of spectrum auctions, development of spectrum user rights, technical and service neutral assignments and authorization;
* Spectrum pricing policies including objectives, use of incentives, basis for recovery, and implementation of market-based spectrum prices;
* Specific policies for refarming and re-allocation done in conjunction with the development of spectrum user rights, valuation and spectrum pricing.

Best practice core principles include the following:

* Spectrum should be allocated to the highest value uses or uses to ensure maximum benefits to society are realized;
* Mechanisms should be put in place to enable and encourage spectrum to move to its highest value use;
* Greater access to spectrum will be facilitated when the use the least cost and least restrictive approach is chosen in achieving spectrum management goals and objectives;
* To the extent possible, regulators and spectrum managers need to promote both certainty and flexibility;
* Balance the cost of interference with the benefits obtained from greater spectrum utilization.

The spectrum is a national resource and must be managed efficiently so as to be of the greatest benefit to the entire population. This spectrum management usually takes place within a regulatory framework comprising legislation, regulation, procedures and policies. One of the most important tools for effective spectrum management is the National Table of Frequency Allocation (NTFA). This shows how the spectrum can be used in the country.

### **2.5.1 Spectrum Management Assessment**

Key elements of national spectrum management for review and assessment are:

* *Country background* such as political, economic, topographic, geographic, geographic, demographic and radio communications development requirement influences on radio spectrum management. Therefore, the national spectrum management approaches could be unique for each country.
* *Legal Framework* for Spectrum Management: It includes the primary legislation to establish the legal right of the State to manage radio spectrum, identify and define “The Administration”, charge for spectrum use and management, and develop the National Table of Frequency Allocations and the secondary legislation that includes regulatory codes of procedure, statutory instruments etc. To check whether the legal framework establishes or not the assessment objectives could be:
	+ Legal certainty (e.g. spectrum availability) to spectrum stakeholders and investors
	+ Efficient and equitable spectrum management procedures
	+ Fair and transparent procedures (for licensing, fees, dispute resolution)
	+ Consultative procedures (stakeholders, operators, users, industry)
	+ Monitoring for control of spectrum quality (compliance, interference, efficient use)
	+ Equipment standards and certification, putting on the market, import
	+ International negotiations – frequency coordination, ITU representation
	+ Support/fund spectrum efficiency research
	+ Pro-active spectrum efficiency improvement by facilitating (e.g.) re-farming
* *Organizational Structure* of Spectrum Management: As per the Telecommunications or Radiocommunications Act should identify and establish the Administration-the legal entity with overall responsibility for national spectrum management and interface with the ITU. The Administration could be a government Ministry or one of its departments, a state institution or an independent regulator. The Administration (or the Act) may also delegate some spectrum management responsibilities in nationally allocated bands for specific purposes to other government agencies, telecommunications operators (e.g. of public fixed and mobile services) or similar large organizations that make extensive use of radio in their operations. To this purpose the assessment objectives could be:
	+ Provide a clear description of the organizational structure of spectrum management, in particular to determine whether there is more than one organization responsible for spectrum management.
	+ The Administration should be identified and a description should be provided of the functional structure of the Administration together with staff numbers and responsibilities.
	+ The legal relationship with other main spectrum users (government ministries, agencies or operators) should be described; especially if they have delegated powers for spectrum management.
	+ The effectiveness of the coordination arrangements between Administration and other main spectrum users should be examined (described later).
* *Current Spectrum Allocation & Usage as well as Future Trends*: An examination of national spectrum allocations and use can provide a measure of the effectiveness of spectrum management planning policies and day-to-day frequency assignment procedures. The assessment objective could be:
	+ Obtain and examine the National Frequency Allocation Table;
	+ Determine the amount of spectrum allocated to government and nongovernment services; Is there a rationale for this division;
	+ Determine the sub-division of spectrum for various non-government applications;
	+ Obtain from licensing records/statistics a measure of the actual use (i.e. number of assignments) for each user category;
	+ Identify systems, services or bands that have congestion or other spectrum availability difficulties.
* *Spectrum & Apparatus Assignment/Licensing Processes/Mechanisms:* It includes the international licensing requirement and national licensing arrangements. The national licensing arrangement must be done with higher flexibility.
	+ Individual licensing: Usually required for “international” stations (e.g. aeronautical and maritime mobile) and for those transmitters which required individual frequency planning (e.g. interference analysis) including international coordination?
	+ A general licensing regime: May be used for personal transmitters operating under the control of public mobile telephone networks designed to meet international standards. Various short range devices, including computer terminals in wireless local area networks, can operate under a general “license exempt” basis, provided that the equipment conforms to an accepted standard on agreed frequencies.
	+ To describe the licensing system in operation, including what types of system require a license and whether there is a license exemption arrangement or general license for certain systems e.g. SRD, WiFi etc. The following procedures are especially important:
		- Is the application procedure easy to understand and published?
		- Are all application registered (to track progress through the system)
		- Are there qualified staffs for technical analysis?
		- Is decision-making fast and efficient
		- What options are there for payment of licensing fees and charges
		- How is the license issued (in person, by post, electronically etc.)
		- License renewal (period of validity)
		- Is there any computerization of the licensing process (any planned)
* *Financing Spectrum Management and Pricing*: The spectrum users benefit from the planning, management and monitoring of the spectrum carried out by the State or by other organizations delegated by the State. It is therefore reasonable and lawful for the State or spectrum management organizations to require users to pay administrative fees (known also as frequency management fees or service fees), as well as administrative charges to cover all costs arising out of spectrum planning, management and monitoring activities (cost recovery). Meanwhile, the Market Approaches to Spectrum Management go beyond simple cost recovery (described above) and become spectrum tools in themselves by placing a value on the spectrum. These tools (including opportunity costs and auctions) can: *be designed to promote spectrum efficiency; assist when spectrum demand exceeds supply; determine the most cost beneficial spectrum use; and encourage innovation and adoption of newer/more efficient technologies.* The Assessment objectives could be:
	+ Is there a well defined financial strategy for meeting the total costs of managing the spectrum?
	+ Does the spectrum management authority publish its annual operational budget?
	+ Are budgets well-balanced, costs fairly distributed between licence groups, with those requiring the most spectrum management resources paying higher fees?
	+ Is there a simplified fee structure and collection mechanism with a simplified licensing scheme?
	+ Are licensees able to easily choose a license “product” that meets their needs and see how much it will cost, both for any initial fee and the annual renewal fees?
	+ Are auctions run in accordance with established good practice?
* *Spectrum Quality Control, Interference Management & Enforcement:* In order to guarantee that spectrum use conforms to existing regulations and the authorizations granted, there should be some form of spectrum monitoring capability. The main purposes of spectrum monitoring are to measure spectrum occupancy (to evaluate effectiveness of spectrum planning and identify geographical areas and bands having congestion), verify administrative (licensing) database records, check technical compliance, resolve interference, and trace unlicensed/illegal use. Assessment objectives (to determine) could be:
	+ The type of monitoring facilities available and the extent to which they are used (e.g. regular monitoring programmers to target particular issues)
	+ The experience of the staff and how monitoring is integrated into general spectrum management activities
	+ If the national regulations contain enforcement measures (e.g. financial penalties) intended to deter interference from unauthorized use, noncompliance with the allocation, assignment or authorization etc.
* *Spectrum Management Databases and Computer Assisted Assignment:* Record keeping of administrative and technical data is an essential requirement of spectrum management. The data may be stored on a paper-based system but computerized systems are more efficient. Whichever format is chosen, the key elements are: accuracy, sufficiency, security and control, data entry validation, ability to search and analyze, and ability to interface with other systems (especially national monitoring). The assessment objectives are:
	+ The assessment should identify all databases used in the country; in particular the database used by the administration/regulator but also those used by delegated agencies and operators;
	+ The design of the database(s) should be noted (e.g. MS Access), data fields used (e.g. conform to ITU recommendations), ease of transfer;
	+ Examine the procedures used to validate application data (in particular the accuracy of transmitter location);
	+ Networking capability;
	+ Security and backup arrangements.
* *Application of spectrum engineering in spectrum management and assignment:* Spectrum engineering is the application of engineering practice and principles to ensure that spectrum plans are designed to make effective and efficient use of the spectrum and maximize the number of different radio systems that are able to operate as intended in any given frequency band. Spectrum engineering analyses used as technical input to spectrum planning in two ways: to plan the spectrum to enable systems with defined technical and operational characteristics to operate as intended; or to determine the technical and operational characteristics necessary to enable systems to work in a specified frequency plan. Spectrum engineering must also take into account design and equipment costs to ensure the economic viability of engineering solutions to spectrum management problems. Assessment objectives are:
	+ To what extent is spectrum engineering used in EMC and interference analysis for new frequency assignments and national allocation system planning
	+ What services (e.g. fixed, mobile, broadcasting) benefit from application of spectrum engineering
	+ What spectrum engineering tools and models are used? In particular, are ITU tools and models used for international frequency coordination and allocation plans
	+ Is propagation modeling used and is high resolution terrain data available
	+ Are computer tools available for spectrum engineering
* *Equipment standards:* Documents which specify the minimum performance requirements for radio transmitters and receivers (or other equipment) and the associated procedures to ensure conformity with these requirements are commonly referred to as “equipment standards”. Standards can be developed by national, regional or international organizations such as ITU. The obsolete procedures are nationally developed standards and every country requires a sample to be submitted to its own government-run laboratory for “type-approval” to the relevant national standard before market. The new procedures are a combination of manufacturers’ declaration of compliance (compliance testing by commercial test-houses, market surveillance) and global standards. To examine and describe the radio equipment standardization certification and import procedures and determine whether these:
	+ Are efficient: quickly enable users to implement their new radio systems by ensuring suitable and approved equipment may be obtained from a variety of legal sources (manufacturers/dealers) at reasonable cost;
	+ Are open and flexible: where possible, authorizing compatible standards from a wide range of regional standards bodies and accepting equipment certification from internationally recognized test-houses;
	+ Are transparent: publishing the equipment specifications required for each frequency band and service so that users know what to purchase;
	+ Are “import-friendly”: publishing the import requirements that have been notified and agreed with the customs authorities to ensure properly certificated equipment may be imported easily.
* *Participation in International Spectrum Planning and Coordination activities:* National Radiocommunications exist within an international (global, regional or bilateral) framework of regulation, legal commitments, operational and commercial realities. The national spectrum manager’s ability to participate in international fora (and influence outcomes) becomes significant because all the international (global, regional or bilateral) spectrum management decisions will have an eventual impact on national legislation, regulations and spectrum use. Assessment objectives are:
	+ Is there a requirement for cross-border coordination, if so is this given some priority;
	+ Does the administration carry out its obligations of notification and coordination in accordance with ITU procedures;
	+ Are there bi-lateral or multilateral coordination arrangements (and meetings);
	+ Does the administration organize co-ordination or is there informal border coordination between operators;
	+ Does the administration participate in international or regional preparations for World or Regional Radio Conferences;
	+ Are there national preparations for WRC
* *Participation of Stakeholders in the Spectrum Management Process*: Spectrum stakeholders are the government and non-government spectrum users that depend on Radiocommunications to function efficiently. Consultation with these stakeholders is essential in virtually every aspect of spectrum management, including the development of national legislation and regulations, spectrum policies, technical standards, etc. The type and extent of consultation depends on government policy and how the institutional authority for spectrum management has been organized--detailed and regular consultation and less regular but major changes. For detailed and regular consultation establish working groups or committees with membership drawn from relevant government departments and other agencies, include: major non-government spectrum stakeholders (e.g. service providers, telecom industry, broadcasting organizations), and allow associations or bodies representing groups of users to contribute (not practical to consult with each individual spectrum user). For less regular but major changes advance publication of proposals with invitation to comment, publish responses and publish decisions and reasons. Assessment objectives are:
	+ Examine and describe the procedures in place for consultation with spectrum stakeholders;
	+ In particular determine which stakeholders are invited to participate and
	+ Is there transparency and fairness;
	+ Is there a “national strategic spectrum planning committee” of major stakeholders
	+ Are there working groups of stakeholders to advise the administration on specific spectrum management issues
* *Research Collaboration with Institutions of Higher Learning and Industry:* Research collaboration objectives and benefits are research projects to improve spectrum management and efficient utilization, for administration with limited staff and resources, provides external source of academic knowledge and facilities academic institutions and students may be provided with the challenge of real spectrum management issues, method of interesting and attracting a future generation of engineers and related professions into careers in spectrum management, and collaboration with telecom industry ensures the administration develops a practical understanding and industry understands the benefits of good regulation.
* *Public Information:* It is needed for easily accessible, up-to-date and comprehensive spectrum information. All those involved in radio-communications and telecommunications (users, potential users, operators, equipment suppliers etc.) need to be able to access, quickly and easily, timely an information about: how spectrum is used (NTFA), what spectrum is available for particular purposes (NTFA), equipment specifications and standards (for each band/purpose), licensing processes and types, regulations and fees, proposed changes to regulations and spectrum use, opportunities and procedures to participate in the consultative process. Information distribution through the internet and the administration’s web-site is replacing the traditional official government gazette or journal. In the on-line licensing procedures, the following licensing facilities should be available on-line: applications (in particular for “simple” licenses), renewals, and electronic payments. An overall description of the administration’s public information facilities should be given, noting:
	+ Does the administration have a web-site?
	+ Is it well maintained and up-to-date?
	+ Does it contain key items (e.g.)?
	+ Is the Radiocommunications legislation publicly available?
	+ Is the National Table of Frequency Allocations (NTFA) available?
	+ Is there a schedule of services and applications and available frequencies?
	+ Is there a schedule of fees and charges? etc.

## **2.6. Current practices in Spectrum Management in SATRC region**

The responses from Afghanistan, Bangladesh, Bhutan, India, Islamic Republic of Iran, Maldives, Nepal, Pakistan and Sri Lanka on the questionnaires prepared by SATRC have been analyzed and generalized to assess the current practices of SATRC members in spectrum management.

### **2.6.1 Policy Formulation and Implementation**

In Bangladesh, Maldives and Sri Lanka, it is the same authority that does spectrum policy formulation and implementation. However, the spectrum policies of Bhutan, India, Iran, Nepal and Pakistan are formulated by the government while implementation of the policy is carried out by the regulatory body.

Manpower involved in the process differs hugely from countries to countries. The approximate numbers of staff involved in spectrum management is Bhutan, India, Iran, Nepal and Pakistan is five, one hundred, twenty three, eight and seventy respectively. The numbers indicate some countries have extremely low numbers of staff assigned for spectrum management with respect the provision made in Handbook on National Spectrum Management (Edition of 2015) as shown in Fig. 5.



*Figure 5: Spectrum management organization of professional staff*

|  |  |  |
| --- | --- | --- |
| **Country** | **Policy Formulation** | **Policy Implementation** |
| Afghanistan |  Ministry of Communications and Information Technology (MCIT) |  Afghanistan Telecom Regulatory Authority (ATRA) |
| Bangladesh | Bangladesh Telecommunication Regulatory Commission (BTRC) | BTRC, Ministry of Posts, Telecommunications and IT |
| Bhutan | Ministry of Information and Communication | Bhutan InfoComm and Media Authority (BICMA) |
| India | Ministry of Communications | Telecom Regulatory Authority of India (TRAI) |
| Iran | Ministry of Information and Communication Technology | Communications Regulatory Authority (CRA) |
| Maldives | Communications Authority of Maldives (CAM) | Communications Authority of Maldives (CAM) |
| Nepal | Ministry of Communication and Information Technology | Nepal Telecommunications Authority (NTA) |
| Pakistan | Ministry of IT & T | Pakistan Telecommunication Authority (PTA), Pakistan Electronic Media Regulatory Frequency Allocation Board (FAB) |
| Sri Lanka | Telecommunications Regulatory Commission (TRC) | TRC |

*Table 1: Spectrum policy formulating and implementing bodies in SATRC region.*

### **2.3.2 Legal framework and national frequency allocation table**

Spectrum management in SATRC countries is being implemented based on the legal framework formulated by the government. As reported by Iran, the basic principles in the spectrum management framework are to achieve the highest economic efficiency, achieve the highest technical efficiency and increase social development and satisfaction.

The frequency allocation tables in SATRC countries are updated as and when required. In Afghanistan, it was planned to update the frequency allocation table every 4-5 years but was updated in 2017 after almost 12 years. Afghanistan, Bhutan, Iran, Nepal, Pakistan and Sri Lanka update the table every 4/5 years, normally after the WRC. The frequency allocation plan of India was revised in 2018 after 7 years. The national frequency plan of Maldives is ready, under review, and yet to be published.

|  |  |
| --- | --- |
|  **Country** | **Key Legal Framework** |
| Afghanistan | Telecom Services Regulation Law<http://atra.gov.af/Content/files/1%20Telecom%20Service%20Regulation%20Law%20of%20ATRA.pdf>Radio Frequency usage regulation |
| Bangladesh | Bangladesh Telecommunication Control Act, 2001<http://www.btrc.gov.bd/sites/default/files/telecommunication_act_english_2001.pdf>National Frequency Allocation Plan (NFAP) |
| Bhutan | National Radio Rules<https://www.bicma.gov.bt/bicmanew/data/publications/rules-regulations-guidelines/Radio_Rules_2011.pdf> |
| India | Indian Telegraph Act, 1885, Indian Wireless Telegraphy Act<https://dot.gov.in/act-rules> |
| Iran |   |
| Maldives | Telecommunications Law 43/2015 |
| Nepal | Telecommunications Act, 2053 (1997)<https://nta.gov.np/wp-ontent/uploads/2012/06/Telecom%20Act%20Upto%20date%20Eng.pdf>Spectrum Policy<https://nta.gov.np/en/spectrum/> |
| Pakistan | Pakistan Telecommunications Re-organization Act 1996 |
| Sri Lanka | Sri Lanka Telecommunications Act 1991 and 1996 (Amended)<http://www.trc.gov.lk/images/pdf/Act25_1991_Eng.pdf><http://www.trc.gov.lk/images/pdf/Act27_1996_Eng.pdf> |

Table: Key legal frameworks for spectrum management in SATRC countries.

|  |  |
| --- | --- |
| **Country** | **National Frequency Allocation Table and update interval** |
| Afghanistan |  4-5 years (planned), 12 years (latest update) |
| Bangladesh | <http://www.btrc.gov.bd/sites/default/files/National%20Frequency%20Allocation%20Plan%20%28NFAP%29%202.pdf>4-5 years |
| Bhutan |  4 years (after WRC) |
| India | <https://dot.gov.in/whatsnew/national-frequency-allocation-plan-2018>7 years (latest update) |
| Iran | <https://asnad.cra.ir/en/Public/Documents?parentId=2e2b0e79-a1ab-e911-967d-0050569b0899>4 years (after WRC) |
| Maldives |  Ready for publication |
| Nepal | <https://nta.gov.np/wp-content/uploads/2016/09/National-Frequency-Allocation-Plan-2013.pdf>4-5 years |
| Pakistan |    |
| Sri Lanka | <http://www.trc.gov.lk/images/pdf/FINALRadioFrequencySL.pdf>4 years (after WRC) |

*Table 2: National frequency allocation plan and update interval of SATRC countries*

### **2.3.3 Service and spectrum license**

Mostly, SATRC countries have service licenses that are tied up with spectrum licenses. To apply for and get necessary spectrum, the operators must have service licenses. In Pakistan, the service and spectrum licenses are bundled and the license is issued for the right to use spectrum. India initially had spectrum bundled with the license, but currently distributes the spectrum to the telecommunications service providers via auction.

In Sri Lanka, the frequency licenses are service specified. In Other SATRC countries, the spectrum license is provided on technology neutrality basis. The spectrum licensing procedures of different SATRC countries are described below:

**Afghanistan**

The licensing procedure in Afghanistan is depicted below. The designed workflow is exact, supported by regulations, and optimized to be executable in the shortest possible duration.



*Figure 7: Spectrum licensing workflow in Afghanistan*

**Bangladesh**

In Bangladesh, usually the ‘Auction’ or ‘Over the Counter’ method is followed for spectrum assignment. While assigning spectrum to Telecom Service Provider (TSP), it is the auction method which is mostly used. The following table describes both the methods and explains how transparency and timely spectrum licensing is followed in Bangladesh:

|  |  |
| --- | --- |
| **Spectrum Auctioning Procedure** | **Over the Counter Allocation Procedure** |
| * So far, spectrum is auctioned for the Mobile and BWA Companies only.
* The Commission forms a committee to prepare a ‘Guideline’, which outlines the details of the spectrum use, pricing, legal aspects, auction procedure, licensing conditions etc.
* Spectrum under consideration for auction is placed before the SMC.
* The SMC recommends the proposal for Commission approval.
* The Commission approves the Guideline prepared by the Committee, and sends it to the Ministry, who by Telecom Act is the final authority to approve the Guideline.
* After receiving approved ‘Guideline’ from the Ministry, auction conducted and license is awarded to the successful bidders.
 | * User applies to BTRC in a specified form.
* Request is placed before the Spectrum Management Committee (SMC). SMC is a 16 members Committee, headed by Commissioner SM, formed under the Telecom Act 2001. Other members are from different Govt. Agencies including Security Agencies and Educational Institute.
* SMC either recommends or rejects the application.
* SMC recommendation is placed before the Commission and Commission is the final authority to approve the assignment of the Spectrum.
 |

**Bhutan**

When the application is received from an operator, it is reviewed and spectrum is assigned. Meanwhile, it is ensured that sufficient spectrum is reserved for other existing as well as future operators.

**India**

The Indian Wireless Telegraphy Act, 1933, provides the power to the Central Government to manage the radio waves, issue wireless apparatus license under the law and prohibit certain apparatus to operate. The Radio Regulations, an international treaty signed by India and other Member States of the International Telecommunication Union (ITU), governs the use of radio-frequency spectrum and satellite-orbits (geostationary and non-geostationary) at the global level. From time to time National Frequency Allocation Plan (NFAP) is reviewed and updated to accommodate the spectrum requirements for latest technological developments keeping the global harmonization in mind. Access spectrum bands for mobile cellular services are identified and harmonized for the services. Earlier the Access spectrum was assigned for a specified technology and was bundled with license, however, since 2010the spectrum is assigned through the auction only and also treated as technology neutral i,e, the service provider can deploy the service using any of the standard wireless technology. In the past 10 years, most of the access service bands are refarmed to provide the IMT technologies such as 3G/ 4G and upcoming 5G.

First the bands/ quantum of spectrum to be put for auctions is finalized, the reserve price of the spectrum is discovered by TRAI through consultative process and the price is finally approved by the Digital Communication Commission. Once the bands/ spectrum for auction are finalized by the government, spectrum auctions are held through a transparent online bidding mechanism based on SMRA methodology. The bidding takes several rounds and the winning party is awarded the spectrum once the payments (as prescribed through auctions) are submitted to the government. Spectrum is assigned to the service provider for a period of 20 years.

**Iran**

For ensuring proper transparency of how to issue radio communications' license; relevant processes, costs, licensing duration, license validity, documentations and conditions required are informed in the organization's portal. For example, the following steps are performed for LMR issuing license:

1. Sending request from the applicant
2. Check request and requirements (administration)
3. After the request is approved, send complement documents and requirements (applicant)
4. Final review by the administration
5. Issuance of the license

**Maldives**

In Maldives, the service provider has to request for the assignments in general. After reviewing and consulting with the applicant, the assignment is finalized. The good relations with service providers make the administration ready for the assignment without any delay.

**Nepal**

Till date, Nepal assigns the spectrum to the operators based on the availability and demand of the spectrum. Recently, limited auction was made between the existing licensee for the remaining bandwidth in 900, 1800, and 2100 MHz band. To get the spectrum license, the operators need to file the application with supporting documents, such as roll-out plan, to Nepal Telecommunications Authority (NTA) and NTA issue the license based on the availability of the spectrum and the documents submitted by the operators.

**Pakistan**

Cellular Mobile licensing in Pakistan is dependent on policy directive from the Government. Upon receipt of such a directive, PTA carries out the licensing process which includes preparation of Information Memorandum, consultation with prospective applicants, auction and subsequent award of the license/spectrum. Other wireless licenses are issued as per process shown in the Fig. 6.



*Figure 6: Spectrum Licensing Workflow in Pakistan (where FAB = Frequency Allocation Board, DN = Demand Note, ILF = Initial License Fees).*

**Sri Lanka**

For frequency assignments, Sri Lanka generally follows the ‟First Come First Serve” basis if the spectrum demand has not exceeded the availability. For the cases where the demand is more than the available spectrum, ‟Market Based Mechanism” is applied.

|  |  |  |  |
| --- | --- | --- | --- |
| **Country** | **Service license required for spectrum license?** | **Technology specific or neutral** | **Administrative allocation or auction** |
| Afghanistan | Yes | Technology Neutral |   |
| Bangladesh | Yes | Technology Neutral | Both |
| Bhutan | Yes | Technology Neutral | Administrative only |
| India | Yes | Technology Neutral | Auction only |
| Iran | Yes | Technology Neutral |   |
| Maldives | Yes | Technology Neutral | Administrative only |
| Nepal | Yes | Technology Neutral | Both |
| Pakistan | Yes | Technology Neutral | Auction only |
| Sri Lanka | Yes | Service specified | Administrative only |

*Table 3: Summary of spectrum licensing in SATRC region*

### **2.3.4 Spectrum Pricing**

The price of the spectrum is determined in different countries through various procedures. In Afghanistan and Bhutan, the spectrum fee is calculated by using a formula that reflects the covered area, occupied bandwidth, service type, covered region type, daily usage time, user type, yearly usage duration etc. The spectrum prices in Bhutan are not revised unless the National Radio Rules are revised. Bangladesh has a ‘rate list’ for most services outlining Radio Frequency Charges, with four main components covering frequency charge, power output charge, station/ terminals charge and a license fee. Spectrum for commercial cellular services in India assigned through the auction-based approach, on exclusive rights basis to a single user for his exclusive use. However, the spectrum for non- IMT usage is assigned administratively based on the requirements. Secondary trading of spectrum rights is permitted in India. The formula for calculating frequency fee in Iran comprises geographic, station and frequency coefficient. Maldives assigns spectrum administratively, making service available at low cost. In Nepal, the methods of administrative pricing and auction are implemented for spectrum pricing and the price is revised every 2/3 years. Spectrum price in Pakistan is determined through auction, while Administrative Incentive Pricing and Administrative Cost Recovery are also used for pricing of spectrum that has not been subject to an auction. In Sri Lanka, frequency fees are defined in the relevant government Gazettes.

###  **2.3.5 Regulation of SRDs**

Afghanistan, Bangladesh, Maldives and Pakistan have allocated frequency bands for the purpose of SRD operation while Nepal is in the process of allocating spectrum for SRDs/ UWB. Usage of SRDs is unlicensed in Afghanistan, India and Sri Lanka. Bangladesh exercise ‘Over the Counter’ for assigning spectrum. Iran has a class license for using SRD devices and the license defines technical specifications, conditions of production, and how to implement them. In addition, type approval certificates of the device must be obtained. In Maldives, there is no legal framework for issuing licenses for SRDs but type approval of equipment is necessary.

|  |  |  |
| --- | --- | --- |
| **Country** | **SRD Bands** | **Licensing** |
| Afghanistan | 2400-2483.5 MHz, 5170-5330 MHz, 5490-5730 MHz, 5735-5835 MHz | Unlicensed |
| Bangladesh | <http://www.btrc.gov.bd/sites/default/files/National%20Frequency%20Allocation%20Plan%20%28NFAP%29%202.pdf> | Over the counter |
| Bhutan |   |   |
| India | ISM band, license exempt bands specified in NFAP | License-exempt |
| Iran |   | Class license, device type approval |
| Maldives | 433MHz, 868MHz | Device type approval |
| Nepal | 433 MHZ, 868 MHz, 6-8.5 GHz (under review) | Framework being prepared |
| Pakistan | 433 MHz, <135 kHz, 2.4 GHz, 865-868 MHz, 5.7 GHz ISM band, 24-24.25 GHz | Framework being prepared |
| Sri Lanka |   | Unlicensed, device type approval |

*Table 4: Frequencies allocated for SRDs in SATRC region*

### **2.3.6 Frequency for PPDR**

Afghanistan, Bangladesh, Bhutan, India, Iran and Pakistan report the allocation of frequency for public protection and disaster relief (PPDR). The use of such frequencies by other services in Afghanistan shall be avoided, particularly during periods of emergencies or social unrest. In India, no spectrum is kept as spare for emergency use for commercial cellular networks. However, state owned telecom service providers are assigned additional spectrum to assist the first responders’ agencies and public in rescue operations; additionally, emergency responders including PPDR agencies are authorized to set up and run the network for their captive purposes. In Iran, the allocated radio channels in VHF bands are implemented in political events or natural disaster events. Maldives, Nepal and Sri Lanka have not yet allocated the spectrum but the process is underway. Moreover, the PPDR frequencies are not harmonized across SATRC countries.

|  |  |
| --- | --- |
| **Country** | **PPDR Bands** |
| Afghanistan | 68-88 MHz, 138-144 MHz, 148-174 MHz, 380-400 MHz, 406-430 MHz, 440-450 MHz, 748-758 MHz, 806-824 MHz, 851-869 MHz, 4940-4990 MHz, 5850-5925 MHz |
| Bangladesh | <http://www.btrc.gov.bd/sites/default/files/National%20Frequency%20Allocation%20Plan%20%28NFAP%29%202.pdf> |
| Bhutan |   |
| India | 338-340/ 348-350 MHz, 351-356/ 361-366 MHz, 380-389.9/ 390-399.9 MHz, 806-811/ 851-856 MHz, 811-814/ 856-859 MHz, 819-824/ 864-869 MHz, |
| Iran | VHF band |
| Maldives | Under process |
| Nepal | Under process |
| Pakistan | 4.94-4.99 GHz, 814 – 824/ 859 – 869 MHz |
| Sri Lanka | Not defined |

*Table 5: Frequencies allocated for PPDR in SATRC region.*

### **2.3.7 Cross-border interference**

The issues of cross-border interference, when arises, is being resolved via mutual correspondence and understanding. Afghanistan is in the process of signing bi-lateral agreement with all neighbor countries to avoid cross-border interference. In Iran, interference will be assessed under the procedure set in the agreement if there is an agreement with the neighboring country. If there is no agreement, the subject of interference will be reported to the ITU office according to the ITU procedures. In addition to bilateral talks, Pakistan is reporting such issues to ITU as well. However, there are no any defined procedures and bi- or multi- lateral agreements in effect in this regard.

### **2.3.8 Monitoring**

SATRC members perform spectrum monitoring on an ad hoc basis whenever complaints related to interference are received. Bangladesh, Bhutan, India, Maldives specifically mention that they exercise periodic monitoring of the spectrum independent of any complaints.

In India, Wireless Monitoring Organization of Ministry of Telecommunications carries out wireless monitoring through a network of one International Satellite Monitoring Earth Station, five International Monitoring Stations, twenty-two Wireless Monitoring Stations and 5 Radio Noise Survey Units, strategically located all over India. The field monitoring stations monitor the radio frequency spectrum across the country.

In Bangladesh, there are one Central Fixed Monitoring Station, five other Fixed Monitoring Stations, one portable Monitoring Stations and ten handheld Direction Finders. Bhutan performs spectrum monitoring by using one fixed monitoring station and mobile monitoring using portable receiver and spectrum analyzer. Fixed, mobile and portable stations are used for monitoring in Iran and the obtained data is collected and analyzed at regional and country centers. In Pakistan, the monitoring mechanism is distributed which however is managed centrally. In Sri Lanka, there are three VHF/UHF Regional Monitoring Centers, five VHF/UHF Remote Monitoring Stations, one HF Monitoring Station and one Mobile Surveillance Vehicle.

## **2.4 Effective use of spectrum**

Spectrum is a key and scarce resource that is essential to many sectors and services. Because of its scarce nature and overwhelming demand, efficient and effective use is a necessity. Different actions can be taken by the regulatory administration to ensure maximum benefit from the limited resource.

### **2.4.1 Technology and Service Neutrality**

Restricting the use of spectrum to particular technologies and services exacerbates scarcity of spectrum and prevents customers from gaining access to new services. Removing restrictions that limit the use of spectrum to particular services or technologies (beyond those needed to manage interference) enables a country to maximize the benefits from its spectrum resources on an ongoing basis.

### **2.4.2 Rollout Obligation**

To ensure efficient spectrum usage, the licensing authorities can impose additional obligations on licensees. These obligations can include conditions relating to universal access, such as coverage and service commitments etc. Where a license is assigned using a beauty contest, rather than an auction, commitments to meet non-price criteria can come to dominate the assignment process.

When mobile spectrum was licensed to only a single incumbent operator, imposing a series of obligations as part of that operator’s license represented a relatively straightforward way to achieve particular objectives. However, the development of competition in communications markets raises the need to regularly review which policy objectives remain relevant and which operators should be subject to any obligations. Stringent coverage or service requirements carry risks and can often result in greater costs than benefits.

### **2.4.3 Spectrum Capping**

Spectrum caps have been introduced in several countries at various times to implement competition policy in mobile communications markets. They have been applied to help ensure that no single mobile operator can acquire all or almost all spectrum on offer either at the time of initial spectrum awards or in subsequent mergers of, or deals between operators. The goal of spectrum capping is to prevent operators from gaining positions through large holdings of spectrum, which they might then exploit anti-competitively so as to cause market failures with deleterious effects for customers and overall economic welfare. However, spectrum caps have been substantially modified and even removed in some countries in light of progress in wireless technology, growing demands for mobile services, and the attribution of new spectrum bands for commercial mobile communications.

### **2.4.4 Spectrum Audit**

Spectrum audit is performed to monitor the current spectrum usage, identify and assess the trends that affect spectrum usage, and predict the demand for future spectrum usage. Audit of spectrum usage has to be performed regularly to assess the current spectrum utilization as well as to know of which particular bands are likely to be most in demand for future use. This practice provides valuable input to the regulators for ensuring efficient usage of the assigned spectrum.

# **3. Spectrum Roadmap**

## **3.1 Background**

A spectrum roadmap provides an overview of the technology and market, thus enabling policy drivers to predict the demand for, and manage accordingly the supply of, spectrum over the coming years. A well drafted roadmap takes into consideration the developments in radiocommunications technology and trends of spectrum usage. Indeed, the spectrum roadmap is essential for existing companies and prospective new entrants to the market to ensure that there is enough spectrum to meet the surging demand for telecommunication services, particularly, for mobile services. The pace of mobile technology evaluation is increasing, meanwhile cycle time of new technology is decreasing, and thus there is a demand for an agile spectrum management framework. In this dynamic technological environment, the regulators have to balance the trade-off between the times needed to relocate spectrum against the costs of delaying the introduction of new technologies. If we allocate spectrum in advance the operators will gate time for planning. The role of spectrum-roadmap is of crucial importance for the developing countries to attract foreign direct investment and for the development of the telecommunication sector. It helps regulators to forecast future trends and manage its work and risks and for industry it provides increased certainty about the government’s future allocation plans and management of radio spectrum.

It, thus, informs all stakeholders the near-to-long term planning regarding how and when allocation (making unused spectrum available) and reallocation (better utilizing existing spectrum) activities take place. The spectrum roadmap is needed to address the following challenges:

1. **What spectrum will be available and when:** To plan what and when the spectrum will be available for operators accordingly operators will know what/how to invest in over the near-to-long term to meet rapidly growing demand of telecommunication services that should encompass coverage & capacity bands, existing and future bands.
2. **Regulatory certainty:**  To provide the message about the stability and certainty of spectrum distribution and management related policies e.g. allocation methodologies, renewal procedure, projects and programs of the regulator/government to the existing and prospective operators.
3. **Licensing regime:** To provide clear information about the spectrum management related activities such as refarming, resource pricing, and spectrum sharing to the operators.
4. **Harmonized future spectrum: The spectrum roadmap should plan to** reduce equipment costs, limit interference and enable roaming by providing the harmonized spectrum throughout the region/world.

In addition, the broad goals and objectives associated with spectrum roadmap are:

* Enhancing the capacity of the mobile network.
* Maximizing the economic benefits from use of the spectrum resource.
* Ensuring the users benefit from the use of the spectrum resource.
* Estimating spectrum demand and supply.
* Computing the relation between spectrum and base station sites.

Key themes for a spectrum roadmap includes:

1. the emerging challenges and opportunities to radio spectrum management framework and approach, at least 3 – 5 years into the future;
2. identify future technological trends and drivers, and assess their impact on spectrum policy and planning;
3. spectrum management work projects and program planned to address the identified challenges and opportunities; and
4. a roadmap is an evolving document, to be reviewed and updated regularly (annual review is recommended)[[8]](#footnote-8).

Among many telecommunication services, mobile service is becoming a dominant service, even for broadband access. Therefore, a spectrum roadmap is even more essential to ensure there is enough spectrums to meet surging demand for mobile services.

## **3.2 Global trend on mobile communication**

Mobile communication is one of the most emerging and evolving standards in the field of technology. Initially, it was designed and developed for voice calls/telephone service without any consideration about data services, and it is called 1G mobile technology and was popular around the 1980s. The first generation cellular and cordless telephone networks are based on analog technology with frequency modulation technique with centralized architecture with only Mobile Station (MS), Base Station (BS), and Mobile Switching Center (MSC), poor quality, poor battery, and big physical size.

After the development in technology, specifically in digital signal processing techniques and digital electronics, second generation mobile devices came into the picture in the 1990s. Initially, it was designed to provide phone calls and basic messaging services with fully digital technology and digital modulation technology. 2G provides dedicated voice and signaling trunks between MSCs, and between each MSC and the PSTN (Public Switched Telephone Network). In comparison with 1G, the network controlling structure is more distributed in 2G systems, since mobile stations assume greater control functions such as Mobile assisted handoff (MAHO). However, the data rate supported by the 2G system was very low compared to what was needed for multimedia services.

Meanwhile, the worldwide trend of using public data networks is increasing; 2G mobile has evolved to take advantage of public data networks by introducing new technology called GPRS. The data rate supported by 2G was not enough to handle new emerging services such as data, voice, and video. Then International Telecommunication Union (ITU) formulated a plan to implement global frequency band in the 2000 MHZ range, which will support a single, ubiquitous wireless communication standard for all countries throughout the world with global mobility/roaming service and it was called International Mobile Telephone 2000 (IMT-2000), standard. The IMT-2000 system were expected to provide support for high transmission data rates for indoor and outdoor operations, symmetrical and asymmetrical data transmission, circuit-switched and packet switched services, better voice quality, higher spectral efficiency, multimedia services, global roaming, and economies of scale through open global standards to meet the need of the mass market.

The 3G mobile communication standards were also not able to meet the exponentially growing demand of data services. The cost of the technology has also grown even higher rate, thus there was a bigger challenge to cater the user demand in affordable tariff. Therefore, there was a need for a technology with a packet based network and lower cost to provide a wide range of affordable services to the users. Accordingly, the 4G mobile standards have been developed around 2010. Initially, two standards, let's say Long Term Evolution (LTE) and WiMAX, came to the market. Due to many causes the LTE only evolved (LTE-Advanced) as potential 4G technology as a potential standard meeting the specification made by ITU as IMT-Advanced.

Obviously, mobile communication has a great role for connectivity and its evolution from 1G to 4G has done a tremendous job of connecting the human beings. Experts believe that the 5G goes beyond the previous generations by broadening the connection limits from “Connecting Peoples” to “Connecting Society”. 5G connects virtually everyone and everything together including machines, objects, and devices, as shown in Fig. 7. The 5G networks are emerging not only as the foundation for advanced communication services, but also as the infrastructure supporting socio-economic development and driving industrial digital transformation.



*Figure 7: Usage scenarios of IMT for 2020 and beyond (Source: Rec. ITU-R M.2083-0)*

Indeed, some operators around the world tend to keep a lean layer of GSM for certain time because they are still running some Internet of Things (IoT)/Machine to Machine Communication (M2M) services over General Packet Radio Services (GPRS) & Enhanced Data rates for GSM Evolution (EDGE) (e.g. POS machines, home utilities etc). However, the story of 3G is not going well, accordingly experts believe that 3G is tending towards its death. Therefore, there is also a trend to develop a roadmap to shut down 3G networks so that existing 3G spectrum can be utilized for 4G and 5G in a more efficient way, thus there is a huge trend to migrate all 2G and 3G subscribers to 4G and 5G. This is also supported by the evidence presented by GSMA in the Fig. 8. It shows that in the coming years we will see tremendous growth in 4G and 5G subscription and these will be the major technologies for mobile communication.



*Figure 8: Forecast for 2, 3, 4 and 5G (Mobile World Congress in Barcelona by GSMA)*

To leverage the benefits provided by 5G to the society the regulators should facilitate for its ecosystem development. The cellular communication ecosystem including government regulatory, service providers, equipment vendors and application developers is being driven by the needs and demands of 4G & 5G and making future plans considering these technologies. Meanwhile, spectrum and regulation play a fundamental role in making 5G a success, ensuring timely availability of the spectrum under appropriate conditions to allow the wireless market to respond to consumer and industrial demand for services.

## **3.3 Best practices on spectrum roadmap**

In the world, only few countries are well practicing the spectrum roadmap and they are listed below with key contents available in the roadmap.

**Australia**

Every year the Australian Communication and Media Authority (ACMA) published the Five-Year Spectrum Outlook (FYSO)[[9]](#footnote-9) after the consultation with stakeholders. It includes the:

1. *Proposed key spectrum management activities* with timing for each activity (with quarterly breakdown) and opportunities for consultation and engagement for the financial year.
2. *Anticipated change drivers***:** International trends driving demand for spectrum include the appetite for wireless broadband, particularly in the context of 5G services, ongoing commercialization of Internet of Things (IoT) and Machine to Machine (M2M) applications, advances in broadcasting technology, rapid innovations in satellite technologies, new approaches to spectrum sharing, and government spectrum requirement. For example, analysis of the 5G spectrum from ‘low-band’, ‘mid-band’ to ’high-band considering re-farming and the use of ‘new’ frequency bands. Also considered the Lower Power Devices (LPDs), Short Range Devices (SRDs) and amateur radio.
3. *Proposed annual spectrum management work program***:** Where elements of planning, allocation and activities to improve spectrum management span multiple years, they have identified the relevant timing information. The activities that are grouped according to their main spectrum management functions are international engagement (using APT and ITU Forums), planning (major bands planning, re-planning and optimizing established planning framework), allocations, regulatory review and reform, licensing, pricing, compliance and enforcement. Accordingly, the ACMA is continually monitoring factors that may impact spectrum management including any short-term changes in spectrum demand, technological developments, government priorities and available resourcing. Revising their spectrum management priorities, considering a range of relevant considerations, including maximizing the efficient allocation and use of radiofrequency spectrum, changes in the development, availability and take-up of radiofrequency technologies both in Australia and internationally, spectrum management trends, including through the four-yearly ITU-R WRC process, and the least cost and least restrictive approach to achieve policy objectives.
4. *The forward allocation work plan***:** Timely access to spectrum is of increasing importance to an innovative and dynamic economy. For incumbent and prospective spectrum users, this forward allocation work plan provides information for stakeholders about the planning status and possible timing and sequencing of major spectrum allocations, to better support strategic network planning by spectrum users, technology deployment planning, and capital-raising. Accordingly, they are proposing a set of spectrum bands under consideration for potential future major allocations together with allocation priorities, sequencing and timing considerations.
5. *Spectrum management practice improvements***:** It has been accomplished with help of spectrum management tools such as consultation and publishing the roadmap as an important transparency measure, implementing the recommendations of the government’s Spectrum Pricing Review, continuing to consider industry feedback on its interference management principles, and continuing to work closely with other related stakeholders on proposals for legislative reform, with detailed planned including activities and tentative timing.
6. *Licensing and licensing systems***:** Together other activities include exploring the design of an area-wide apparatus license, review of non-assigned amateur and outpost licensing arrangements with a view to reform, review of non-assigned amateur and outpost licensing arrangements with a view to reform. The potential areas of improvement include determining whether the existing types of apparatus license are still appropriate, and considering reducing the number of types and licensing options where suitable; identifying the key spectrum management issues associated with these license types, including any unnecessary regulatory barriers resulting from the license types; identifying opportunities in the legislative and non-legislative instruments that make up the apparatus licensing framework to reduce complexity and increase transparency for users.
7. *Pricing***:** To implement the recommendations of Spectrum Pricing Review, the ACMA has initiated four substantive programs of work: further identify bands to transition from administratively set charges to competitive market-based allocation in its annual work program; develop and publish Spectrum Pricing Guidelines to provide better transparency and help licensees better understand how the ACMA approaches spectrum pricing; review how the ACMA administratively prices spectrum and the formula used to set many of the current apparatus license taxes. There is potential to improve the ACMA’s administrative pricing of spectrum to more closely reflect market value through approaches, such as opportunity-cost-based pricing; simplify industry’s spectrum management cost recovery arrangements to be consistent with the Australian Government Charging Framework and make them more transparent.
8. *Compliance and enforcement***:** Priority compliance area (PCA) program focused on interference management, spectrum review implementation, and licensing integrity.
9. *Progress achieved***:** The progress has been achieved in the field oflicensing integrity, spectrum review implementation, interference management, and compliance.

**New Zealand**[[10]](#footnote-10)

Ministry of Business, Innovation and Employment of New Zealand published a Five Year Spectrum Outlook 2017-21 with the objective to provide an overview of the areas of growth and development in spectrum management, review emerging wireless technologies impacting on the use of the radio spectrum and outline the Radio Spectrum Management (RSM) work program. In the outlook, the discussion is focused in five areas: Spectrum trends (emerging spectrum management approaches and issues), developing technologies (evolving wireless services, standards and applications), sector developments (demands and issues at sectoral level), spectrum management activities (work carried out through our regular national spectrum management functions), and RSM work program 2017-2021(projects ahead in response to national demands and international developments).

*New Zealand Spectrum Management Framework:* The regulation of the radio spectrum is oriented at reaching the following objectives:

* Achieving the Government’s social, cultural and economic outcomes
* Maximizing the radio spectrum value as input to social and economic development
* Meeting the growing demand for wireless services
* Promoting healthy competition
* Ensuring an environment free of harmful interference for the sustainable development of wireless services and applications

*Spectrum Trends Driving Change***:** The most noticeable trend in the last decade has been the significant increase in the uptake of wireless broadband, with its dependent mobile applications and services, together with the accelerated increase in mobile data use. The high demand for spectrum access in key frequency bands makes interference management vital for ensuring the long-term sustainability of wireless infrastructure. Emerging solutions aiming at balancing spectrum access and manage harmful interference include: a) more efficient and smarter wireless technologies, b) ongoing planning of international allocations and, c) additional flexibility in spectrum authorization mechanisms in some bands under specific conditions (as shown in Fig. 9).



Figure 9: Key approaches looking for maximizing spectrum use and managing interference

*Sector Developments:* It includes mobile broadband, broadcasting, public safety communications, and connected ecosystem: Internet of Things (IoT), Machine-to-Machine (M2M) communications and Intelligent Transportation Systems (ITS), science and space, fixed service, aeronautical and maritime, etc.

*Radio Spectrum Management activities:* Radio Spectrum Management (RSM) is responsible for efficiently and effectively managing the radio spectrum. One of the major responsibilities is allocating rights for the use of the spectrum and enforcing compliance. It includes the following: policy and planning: recent projects include license fees review, act review, Review of the management rights and renewal in different frequency bands, inter agency and international engagement, licensing and registry, RSM compliance, etc.

*Radio Spectrum Management indicative work programme:*Itoutlines the major activities and projects over the upcoming outlook period and provides a brief description of each activity.

**United Kingdom**

Ofcom’s Annual Plan; UK set their priorities such as better broadband and mobile – wherever you are, fairness for customers, supporting UK broadcasting, raising awareness of online harms, supporting consumers and industry through Brexit, enabling strong and secure networks, increasing diversity and inclusion, sustaining the universal postal service, and continuing to innovate our approach to regulation, for the coming financial year.

The report *market context*, highlighting the following: the internet plays a key role in most people’s lives, providing benefits while also raising concerns for consumers; growth in online services is enabled by telecoms infrastructure, which requires further investment; TV content is widely viewed and broadcasters are adapting as audiences increasingly view content online; radio is adapting to an increase in online listening; e-commerce is driving growth in parcel delivery while electronic communications are causing letter volumes to decrease.

The report presents an action plan to achieve/implement their priority e.g. better broadband and mobile – wherever you are realized by helping to improve mobile coverage, particularly in rural areas by exploring policy options and technologies for improving mobile coverage (“We will prepare to award spectrum bands (700 MHz and 3.6 - 3.8 GHz) as they are cleared and released and will continue to develop proposals for new license obligations that would require improvements in mobile coverage in rural areas. A statement will be published in Q3, with auction applications expected to begin in December 2019”.), improving opportunities for spectrum sharing, and preparing for the launch of 5G mobile services.

The report also present the work plan for every fiscal year with projects details and mile stone such as 700 MHz spectrum clearance, broadband Universal Service Obligation (USO) by Q1, developing an updated spectrum management strategy stakeholder engagement workshops by Q2, enabling additional spectrum for mobile including 5G services, spectrum sharing and improve mobile coverage (spectrum solutions).

## **3.4 Current practices in SATRC region**

**Afghanistan, Bangladesh, Maldives , and Srilanka:**

Afghanistan, Bangladesh, Maldives , and Srilanka do not have any spectrum roadmap till date.

**Bhutan:**

Bhutan does not have a spectrum management roadmap, as such but the National Radio Rules consist of all these.

**India:**

India does not have a spectrum roadmap as such but the Department of Telecommunications has prescribed National Digital Communication Policy in 2018 which is a roadmap for next 5 years. Policy Objectives on Spectrum Management as per National Digital Communication Policy (NDCP) 2018 are:

* Recognizing Spectrum as a key natural resource for public benefit to achieve India’s socio-economic goals, ensure transparency in allocation and optimize availability and utilization by:
	+ Developing a transparent, normative and fair policy for spectrum assignments and allocations
	+ Making adequate spectrum available to be equipped for the new broadband era: Identifying and making available new Spectrum bands for Access and Backhaul segments for timely deployment and growth of 5G networks.
		- Making available harmonized and contiguous spectrum required for deployment of next generation access technologies
		- Further liberalizing the spectrum sharing, leasing and trading regime
		- Coordinating with Government departments for freeing underutilized/ substitutable spectrum, and its assignment along with unutilized spectrum for efficient and productive use
		- Optimal Pricing of Spectrum to ensure sustainable and affordable access to Digital Communications
		- Simplifying the process of obtaining permissions from various agencies such as WPC and SACFA in order to promote efficiency
		- Enabling Light Touch licensing/ de-licensing of spectrum for broadband proliferation
		- Promoting the co-use/ secondary use of spectrum
		- Constituting a Spectrum Advisory Team (SAT) consisting of experts, industry and academia to facilitate the identification of new bands, applications and efficiency measures to catalyze innovation and efficient spectrum management
	+ Efficient spectrum utilization and management:
		- Ensuring the optimum utilization of spectrum by management of interference free spectrum and encouraging new technologies and consolidation
		- Monitoring efficient utilization of spectrum by conducting systematic audits of the spectrum allocated to both commercial and government organizations
		- Deploying dynamic database systems for allocation/interference management
		- Publishing annual spectrum utilization and availability roadmap for communication needs including those of aircraft and vessels
	+ Promoting Next Generation Access Technologies in India through the following actions:
		- Encouraging licensed service providers to utilize next generation access technologies to ensure cost optimization, service agility and new revenue streams
		- Recognizing mid-band spectrum, particularly the 3 GHz to 43GHz range, as central to India’s strategy for Next-Generation Networks
		- Promoting the effective utilization of high capacity backhaul E-band (71-76/ 81-86 GHz) and V-band (57-64 MHz) spectrum in line with international best practices
		- Rationalizing annual royalty charges for microwave links for backhaul connectivity
* Ensuring a holistic and harmonized approach for harnessing Emerging Technologies
	+ Synergizing deployment and adoption of new and emerging technologies by:
		- Creating a roadmap for emerging technologies and its use in the communications sector, such as 5G, Artificial Intelligence, Robotics, Internet of Things, Cloud Computing and M2M
		- Simplifying licensing and regulatory frameworks whilst ensuring appropriate security frameworks for IoT/ M2M / future services and network elements incorporating international best practices
		- Earmarking adequate licensed and unlicensed spectrum for IoT/ M2M services
		- Encourage use of Open APIs for emerging technologies
	+ Promoting innovation in the creation of Communication services and network infrastructure by Developing a policy framework for ‘Over The Top’ services
	+ Ensuring the Transition to IPv6 for all existing communications systems, equipment, networks and devices
	+ Enabling High-speed internet, Internet of Things and M2M by rollout of 5G technologies

**Iran:**

Iran is waiting for market requests the market and relative demands will define us what roadmap we have. However, we are developing our roadmap by considering the following items:

* The increasing pace of mobile technology evolution and the decreasing cycle time for new technology demand increased agility in spectrum management and planning framework;
* Allocate spectrum for new uses in advance of the technology becoming available so that operators have time for planning, capital expenditure, and implementation;
* Identify future technological trends and drivers, and assess their impact on spectrum policy and planning;
* Plan what spectrum operators need to invest in over the near-to-long term to meet rapidly growing data demand;
* Consider allocation methodologies, renewal procedure, reforming, resource pricing, spectrum sharing;
* Consider the efficiency of spectrum utilization within the bands assigned to operators;
* Releasing 700 MHz and 800 MHz frequency bands from broadcasting service and other frequency bands;
* Planning the frequency bands which are introduced to IMT on WRC-15 and Precluding use of them for any other services;
* Reforming previous assignment frequency bands.

**Nepal:**

Till date Nepal does not have any spectrum roadmap but is in the process for developing spectrum roadmap for mobile technologies. Recently, higher importance has been given for its development by the government of Nepal. The mobile spectrum roadmap is in the process of finalization and hope it will be finalized by this year.

**Pakistan:**

The spectrum roadmap has been prepared in line with Telecom Policy which is called Spectrum Master Plan. The same is under process of approval of the Federal Government and it is not published yet.

## **3. 5 Developing Spectrum Roadmap-key activities**

It is the responsibility and authority of the government and the regulator to prepare a well-defined Spectrum Roadmap. During the process of drafting spectrum roadmap, all stakeholders including network and service operators as well as equipment vendors should be consulted. Not only does it make the framework more reality-oriented rather than policy-oriented, but the inclusiveness also makes its implementation easier.

The spectrum load map may have the following:

* *Background:* It may include introduction, motivation and objectives of the spectrum roadmap.
* *International and regional practices:* Recent international trend in the field of mobile technology considering the activities and decisions by recent World Radio Conference (WRC), such as spectrum allocation for IMT by WRC-19 and proposed work item for WRC-23.
* *National need and scenario analysis:* Analyze the national need such as traffic demand trend, service diversification trend, core application and requirements, service penetration, coverage penetration, need, spectrum demand, telecommunication market, etc. During the trend analysis also use some technical tools for the forecasting.
* *Exciting spectrum related policy analysis:* In this phase, considering the results of need and scenario analysis and international and regional practice analyze the allocated and assigned spectrum and overall spectrum utilization.
* *Preparation of frequency management roadmap:* Develop the roadmap with each work with brief description and expected outcome and schedule for each activity and tentative date of the completion. From the work to be performed, the activities can be determined by using the planning tool such as Work breakdown structure (WBS). This roadmap may include the possible actions/activities and implementation schedule for the next five year.
* *Periodical review:* The spectrum roadmap may be prepared for five year duration, but it is recommended to revise/update every year, if necessary.

Meanwhile, the spectrum roadmap shall incorporate the following issues:

* Planning
* Allocations
* Pricing
* Regulatory review and reform

### **3.5.1 Planning**

Good planning can facilitate radiocommunication growth and improve economic and social benefits. Planning is necessary for addressing the demand for more spectrums, for preventing interference and for the identification of spectrum for future needs. Planning should take into account factors such as major spectrum shifts, emerging technologies, new services that need allocation, projected crowding in specific bands, developments in international spectrum harmonization etc.

As mentioned above, available spectrum should be harmonized globally or regionally based on international practices. This uniform allocation of radio frequency across an entire region enables international roaming, interoperability, and helps to reduce the capital expenditure related to the equipment (both network infrastructure and user devices). Harmonization also reduces the cross-border interferences.

Prior plans should be prepared to address the demand caused by major spectrum shifts and crowding in specific bands. When there is evidence of changes in the optimal use or uses of bands, it should be identified that there is a net public benefit in the band moving to a new or changed use or being re-configured to better support an existing use. Consulting where appropriate with existing and future users, the concerned Authority should consider how to best accommodate additional uses or users within the available spectrum.

The plan must foresee emerging technologies and new services and identify new allocations accordingly. To avoid the delay in deployment of new generation services, a responsive timeline has to be prepared and followed firmly. As new services demand larger bandwidth, fragmented spectrum should be refarmed and contiguous spectrum with sufficient bandwidth should be made available. Capacity bandwidth (high frequencies) and coverage spectrum (low frequencies) can be bundled to ensure high speed mobile broadband across the country and greater social-economic benefits.

Coexistence between different generations of technologies in the same band and different services in the same technology should be considered during planning. Planning arrangements in bands should also enable the allocation of spectrum to specific users with no, or minimal, further regulatory intervention, and may remain stable over long periods of time.

### **3.5.2 Allocation**

Using sufficient spectrum is the easiest and cost-effective way of increasing radio network capacity in terms of users and speed. Alternative methods, such as small cells and heterogeneous networks, to create high capacity networks require extra equipment and operational cost as well as additional power. Hence, additional spectrum is a central component for affordable, reliable and ubiquitous broadband service and the Spectrum Roadmap should address this requirement.

Frequency allocation is the fundamental element of spectrum roadmap. While planning and allocating frequencies for different purposes, national scenarios and needs should be considered. In addition, the policy formulating body should bear in mind the international compatibility to avoid harmful cross-border interference. This allocation provides information for stakeholders about the planning status and tentative allocation timing and sequencing of particular spectrum bands, to better support the strategic network planning by spectrum users, technology deployment planning and information relevant to capital-raising activities.

The national frequency allocation table should be derived from the international table of frequency allocations of the Radio Regulations (RR). This table serves as the primary source of information regarding what frequency bands are available for which services. The timeline of related actions such as allocation, reallocation, refarming, price adjustment etc. also equally important and provide supplementary information related to the frequency allocation table. The allocation and licensing of the spectrum should provide a level playing field to the entire operators. The regulator should consult with the industry and study the market independently while finalizing allocation methodologies and timelines. Information About demand for access to specific bands from prospective spectrum users also provides important input to allocation decisions.

### **3.5.3 Pricing**

The quality of service offered by an operator is determined by the amount of spectrum it possesses. The price of the spectrum should be set properly to encourage an operator to acquire the spectrum demanded by its network without reluctance. An appropriately priced spectrum also results in affordable service to the users and better quality of experience. When the frequency fee appeals the operators to acquire more spectrums, less numbers of equipment will be installed for the same capacity. Hence, pricing mechanism is a pivotal part of the spectrum roadmap.

Spectrum pricing should align with the objectives of optimal spectral efficiency, achieving economic and social development goals and recovering spectrum management costs. In addition, the government and the regulator should set the optimal value for the spectrum that ensures the orderly growth of the sector. Although auction is evolving as the preferred way to determine the market price of the available spectrum in different spectrum bands, it may not be a logical option in all cases. While determining the administrative price of the spectrum, different approaches can be adopted such as:

* Economic and market analysis
* Technological and service analysis
* Benchmarking of international prices
* Comparison with previous prices determined by auction
* Periodic review of the frequency fee should be performed to confirm the price correctly reflects current demand and supply of spectrum as well as the socio-economic status.

### **3.5.4 Periodic Review and Reform**

As mentioned before, according to the international trend in technology, national trend, and market demand the spectrum release roadmap should be reviewed at least in a year with in depth consultation with the stakeholders, particularly the operators. For this purpose, every country may make a provision of a national spectrum management forum including the representatives from government, regulators, operators, vendors, and others. This forum can be very useful to the regulator for spectrum management.

### **3.5.5 Global Cooperation**

Global cooperation is the fundamental part of national spectrum management and also to develop and implement the spectrum roadmap. The international forum, such as SATRC, APT, and ITU (WRC) may be useful to protect, and sometimes promote the national interest in spectrum management, more specifically for spectrum harmonization and international frequency coordination. Indeed, the engagement is of crucial importance for coordinating international activities and to share information and learning from other spectrum managers on issues of common interest.

# **4. Conclusion and recommendations**

This study report has recommended best practice guidelines for spectrum management and guideline for developing spectrum roadmap for SATRC countries. The recommended guidelines are briefly described below.

## **4.1 Best Practice Guidelines for Spectrum Management**

The spectrum management practices among the SATRC countries have many similarities, yet many differences. Meanwhile the member states are at the stage of drafting their comprehensive National Spectrum Roadmap, the national frequency allocation table and plans are being updated to allocate spectrum for new technologies. While it can be said that the countries in this region are lagging to introduce an effective futuristic spectrum management framework. SATRC members are thus recommended to follow the Best Practice Guidelines for Spectrum Management adopted by ITU Global Symposium for Regulators as follows.

1. **Facilitate deployment of innovative broadband technologies.**

Regulators are encouraged to adopt policies to promote innovative services and technologies. Such polices may include: –

* Managing spectrum in the public interest.
* Promoting innovation and the introduction of new radio applications and technologies. – Reducing or removing unnecessary restrictions on spectrum use.
* Adopting harmonized frequency plans defined by ITU-R recommendation in order to facilitate the implementation of competition.
* Embracing the principle of minimum necessary regulation, where possible, to reduce or eliminate regulatory barriers to spectrum access, including simplified license and authorization procedures for the use of spectrum resources
* Allocating frequencies in a manner to facilitate entry into the market of new competitors.
* Ensuring that broadband wireless operators have as wide a choice as possible of the spectrum they may access, and releasing spectrum to the market as soon as possible.
1. **Promote transparency:**

Regulators are encouraged to adopt transparent and non- discriminatory spectrum management policies to ensure adequate availability of spectrum, provide regulatory certainty and to promote investment. These policies may include:

* Carrying out public consultations on spectrum management policies and procedures to allow interested parties to participate in the decisionmaking process, such as:
* public consultations before changing national frequency allocation plans; and
* public consultations before changing national frequency allocation plans; and service providers.
* Implementing a stable decision-making process that provides certainty that the grant of radio spectrum is done in accordance with principles of openness, transparency, objectivity based on a clear and publicly available set of criterion which is published on the regulator’s website- -and non-discrimination and that such grants will not be changed by the regulator without good cause.
* Publication of forecasts of spectrum usage and allocation needs, in particular on the regulator’s website.
* Publication of frequency allocation plans, including frequencies available for wireless broadband access, in particular on the regulator’s website.
* Publication of a web-based register that gives an overview of assigned spectrum rights, vacant spectrum, and licence-free spectrum, balancing any concerns for confidential business information or public security.
* Clearly defining and publishing radio frequency spectrum users’ rights and obligations, including on the regulator’s website.
* Clearly defining and publishing licensing and authorization rules and procedures, including on the regulator’s website. – Publication of legal requirements for imported equipment and foreign investment, in particular on the relevant government agency website.
1. **Embrace technology neutrality**

To maximize innovation, create conditions for the development of broadband services, reduce investment risks and stimulate competition among different technologies, regulators can give industry the freedom and flexibility to deploy their choice of technologies and decide on the most appropriate technology in their commercial interest rather than regulators specifying the types of technologies to be deployed, or making spectrum available for a preferred broadband application, taking into consideration the need for and cost of interoperable platforms.

* Regulators can take into consideration technological convergence, facilitating spectrum use for both fixed and mobile services, ensuring that similar services are not subject to disparate regulatory treatment.
* Regulators can provide technical guidelines on ways to mitigate inter-operator interference.
	+ - * Regulators can ensure that bands are not allocated for the exclusive use of particular services and that spectrum allocations are free of technology and service constraints as far as possible.
1. **Adopt flexible use measures:**

Regulators are encouraged to adopt flexible measures for the use of spectrum for wireless broadband services. Such measures may include:

* Minimizing barriers to entry and providing incentives for small market players by allowing broadband suppliers to begin operations on a small scale at very low cost, without imposing onerous rollout and coverage conditions, to enable small market players to gain experience in broadband provision and to test market demand for various broadband services.
* Recognizing that wireless broadband services may be used for both commercial and non-commercial uses (e.g., for community initiatives or public and social purposes) and that broadband wireless spectrum can be allocated for non-commercial uses with lower regulatory burdens, such as reduced, minimal or no spectrum fees; regulators can also allocate and assign spectrum for community or non-commercial use of broadband wireless services.
* Recognizing through flexible licensing mechanisms that wireless broadband technologies can provide a full range of converged services.
* Adopting lighter regulatory approaches in rural and less congested areas, such as flexible regulation of power levels, the use of specialized antennas, the use of simple authorizations, the use of geographic licensing areas, lower spectrum fees and secondary markets in rural areas. – Recognizing that in markets where spectrum scarcity is an issue, the introduction of mechanisms such as secondary markets can in some cases foster innovation and free- up spectrum for broadband use.
* Recognizing the role that both non-licensed(or licence-exempt) and licensed spectrum can play in the promotion of broadband services, balancing the desire to foster innovation with the need to control congestion and interference. One measure that could be envisaged is, for example, to allow small operators to start operations using licence exempt spectrum, and then moved to licensed spectrum when the business case is proved.
* The promotion of shared-use bands, as long as interference is controlled. Spectrum sharing can be implemented on the basis of geography, time or frequency separation.
* Developing strategies and implement mechanisms for clearing bands for new services as appropriate.
* Recognizing the need for cost-effective backhaul infrastructure from rural and semi- rural areas, regulators can consider the use of point-to-point links within other bands, in line with national frequency plans, including any bands for broadband wireless access.
1. **Ensure affordability.**

Regulators can apply reasonable spectrum fees for wireless broadband technologies to foster the provision of innovative broadband services at affordable prices, and minimize unreasonable costs that are barriers to entry. Higher costs of access to spectrum further reduces the economic viability in rural and under-served areas. Auctions and tender processes can also be managed to meet these goals.

1. **Optimize spectrum availability on a timely basis.**

Regulators are encouraged to provide effective and timely spectrum use and equipment authorizations to facilitate the deployment and interoperability of infrastructure for wireless broadband networks. Regulators are also encouraged to make all available spectrum bands for offer, subject to overall national ICT master-plans, in order that prices are not pushed up due to restrictive supply and limited amount of spectrum made available and so that opportunities to use new and emerging technologies can be accommodated in a timely manner. In addition, special research or test authorizations could be issued to promote the development of innovative wireless technologies.

1. **Manage spectrum efficiently.**

Spectrum planning is necessary to achieve efficient and effective spectrum management on both a shortterm and long-term basis. Spectrum can be allocated in an economic and efficient manner, and by relying on market forces, economic incentives and technical innovations. Regulators can promote advanced spectrum efficient technologies that allow co-existence with other radio communications services, using interference mitigation techniques, for example, dynamic frequency selection. Regulators can provide swift and effective enforcement of spectrum management policies and regulations.

1. **Ensure a level playing field.**

To prevent spectrum hoarding, especially by incumbents, regulators can set a limit on the maximum amount of spectrum that each operator can obtain.

1. **Harmonize international and regional practices and standards.**

Regulators can, as far as practicable, harmonize effective domestic and international spectrum practices and utilize regional and international standards whenever possible, and where appropriate, reflect them in national standards, balancing harmonization goals with flexibility measures. This could include harmonization of spectrum for broadband wireless access that could generate economies of scale in the production and manufacture of equipment and network infrastructure. Likewise, global harmonization of standards to ensure interoperability between different vendor’s user terminals and network equipment can be promoted. The use of open, interoperable, nondiscriminatory and demand-driven standards meets the needs of users and consumers. Coordination agreements with neighbors, either on a bilateral or multilateral basis, can hasten licensing and facilitate network planning.

1. **Adopt a broad approach to promote broadband access.**

Spectrum management alone is inadequate to promote wireless broadband access. A broad approach, including other regulatory instruments; such as effective competitive safeguards, open access to infrastructure, universal access/service measures, the promotion of supply and demand, licensing, roll-out and market entry measures; the introduction of data security and users’ rights, where appropriate; encouraging the lowering or removal of import duties on wireless broadband equipment; as well as development of backbone and distribution networks is necessary.

## **4.2 Guideline for Developing Spectrum Roadmap**

From this study report, SATRC member countries are found to lack proper spectrum roadmap. It is thus an appropriate time to make an effort to come up with a harmonized Spectrum Roadmap.

In the context of spectrum roadmap development,first and foremost identify the technology trends and drivers in the country, and assess their impact on spectrum policy and the planning. The spectrum roadmap should address the challenges and maximize the benefit leveraged by the spectrum opportunity using the national strength. The roadmap must clearly decimate the information about what spectrum will be available when and must ensure regulatory certainty such as allocation methodologies, renewal procedure, projects and program and licensing regime it may include the clear provision of re farming, resource pricing, spectrum sharing. The roadmap must provide the options for harmonized future spectrum. In the context of developing nations, such as SATRC countries, the development of spectrum roadmap is crucial to attract the foreign direct investment as well.

Learning from the leading regulators around the globe, SATRC member countries are recommended to publish a spectrum roadmap which covers a forward-looking time horizon of three to five years. SATRC member countries are recommended to develop a spectrum roadmap taking into account of policy goals, local market conditions, internationally harmonised spectrum, plan for migration of incumbent users to potential new frequencies and measures to offer potential users the largest possible available contiguous blocks of spectrum. SATRC members are recommended to follow the following steps to develop a spectrum roadmap for three to five years.

1. Review regulatory policy objectives
2. Analyse market demand and industry need for spectrum
3. Review international development and cross-border issues
4. Review the current National Frequency Allocation Plan and update as per latest World Radio Communication Conference outcomes
5. Compare updated National Frequency Allocation Plan with current spectrum assignment database
6. Develop clearance, migration and defragmentation plans to maximize the value of spectrum
7. Develop a roadmap containing assignment priorities and time table.

Following the above mentioned steps, SATRC member countries are recommended to develop spectrum roadmap upon setting out which spectrum bands will be released and when and where possible with any additional information relating to the frequencies such as the band plan and any technical license conditions likely to be attached to the spectrum. While formulating the spectrum roadmap, SATRC member countries are recommended to collaborate with stakeholders. As the spectrum roadmap is an evolving document, SATRC member countries are recommended to review and update the spectrum roadmap regularly with an annual review.

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# **Appendix-I: Questionnaires**

**Introduction**

The evolving wireless technology and the increasing trend of using mobile broadband services realize the need of clear spectrum roadmaps. To ensure consumers and businesses have access to new wireless technologies and services, the government should have a clear roadmap and policy regarding the availability of spectrum to create a conducive environment to the operators for investment. SATRC countries have put in place several spectrum management practices and strategies. However, this is becoming more challenging due to the unbalanced pace of development in technology and services. In addition, the implementation of spectrum management framework and allocation often take a considerable amount of time to take effect.A spectrum roadmap is essential to ensure that there is enough spectrum available in time to meet surging demand for mobile services. The harmonized Spectrum Roadmap is also required to SATRC members to forecast the future and to increase certainty about the regulators regarding future allocation plans and spectrum management. Therefore, it is imperative to assess the current spectrum management practices in SATRC countries and review it for further improvement by developing a spectrum Roadmap.

**Objectives**

The objective of these questionnaires is to collect information on the current status and future plan of spectrum management in SATRC members.

Questionnaire

Question 1:

Describe key provisions in the legal framework for spectrum management in your country.  Provide the corresponding documents or URL.

Question 2:

Does your country have separate agencies for policy formulation and implementation? Describe the organizational structure including the number of staff involved for spectrum management in your country.

Question 3:

Does your country have a spectrum roadmap? If yes, provide the related document or URL.

Question 4:

How frequently national frequency allocation table get updated in your country? Provide the latest table.

Question 5:

Is spectrum license tied up with service license in your country? Does your country have technology neutral provision? If yes, in which band?

Question 6:

How do you ensure transparent and timely spectrum licensing in your country? Describe the exemplary licensing workflow?

Question 7:

What are bands that are using for SRDs in your country? Does your country have any legal framework for issuing licensing for SRDs? If yes, describe the SRDs spectrum licensing procedure.

Question 8:

Describe the spectrum pricing mechanism for different services in your country. How frequently the prices are revised?

Question 9:

Does your country have monitoring mechanism? Whether centralized or distributed? Describe the spectrum monitoring mechanism in your country.

Question10:

How the cross-border interference is being resolved in your country? Is there any bi or multi-lateral agreements in this regard? If yes, provide details.

Question 11:

Does your country have allocated frequency for PPDR? If yes, provide details.

Question 12:

Please provide any additional information on the topic, if not covered above.

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