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MUHAMMED SHITTU LAWAL*, BLAISE NDANDARI, YVES BUTOYA

ABSTRACT

Wetland birds derived innumerable benefits and at the same time plays crucial ecological roles in wetland habitats. However, it is not uncommon that many wetlands are used for rice farming in Rwanda. This project focuses on the consequences of Gahenerezo wetland conversion to rice production on waterbirds. Transect line of 34m by 15m size was used. Simpson's index and Shannon-Winner's Index methods on Abundance and Diversity was also applied. Hypotheses were tested using T-test and Randomized Complete Block Design at 0.05 probability. Result shows Simpson's index was 0.35 and Shannon-Winner's Index was 0.43 for bird abundance in the rice plantation of Gahenerezo wetland. This result translates to slightly low abundance but marginally high diversity of bird. This could be attributed to wetland habitats alteration as a result of farming activities. Farmers applied agricultural chemicals (herbicide, pesticide and fertilizer) which altered chemical composition of the wetland thereby creating ecotoxic environment. Furthermore, there was no significance difference on the abundance of birds in the wetland between morning and afternoon of the days under study Ttab (2.78) >Tcal (0.25). Also, result shows that F-tab (3.18) > F-cal (2.28) which mean there is no significance difference among distribution of bird species in transects in Gahenerezo wetland. In conclusion unchecked rice cultivation has drastically changed bird composition, distribution and abundance in Gahenerezo wetland. In oth-

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er to checkmate the endangering situation and balance conservation and food production objectives, it is crucial there is immediate harmonization of stakeholders interests such as Rwanda Agricultural Board, wetland conservationists, Ornithologists and Rwanda Housing Authority.

Keywords: Marshland, Lowland rice grown area, Cultivators, Aquaticbirds

INTRODUCTION

Wetlands are the most productive natural ecosystems in the world because of the proximity of water and soil. Hence they support large numbers of plant and animal species (https://en.wikipedia.org/wiki/Aquatic_ecosystem, 2020). Wetland birds have been critical components of wetland ecosystem. Complete or partial life needs of these species are met in wetlands. The inherent genetic makeup of some wetland birds makes it difficult for their survival without been closely associated with wetland areas. Wetlands portend irreplaceable transitional nexus between aquatic and terrestrial ecosystems. (Bilby, 1988) said that the terrestrial ecosystems and the aquatic systems intricately interconnected physically, chemically, and biologically at wetlands areas. He further affirmed that a direct expression of the influence of the aquatic system on the terrestrial is the formation of wetlands, an area in which soils are often saturated and inundation may occur periodically. In turn, terrestrial ecosystem may influence the aquatic by dictating the channel form of streams, and providing a primary source of energy and nutrient inputs to the channel. These interactions affect the biotic character of wetlands (Bilby, 1988). Without wetlands, many of the terrestrial and aquatic habitats functions would have been incomplete. The relationship between terrestrial and aquatic system is now

understood to influence many of the functions of wetlands that motivate management efforts (Wetzel, 2001). In the definition of National Academy of Science, USA, (1995), wetland is an ecosystem that depends on constant or recurrent, shallow inundation, saturation at or near the surface of the substrate. Because of the high nutrient of the wetland, many have been converted to farmland for agricultural purposes which have negative consequences for individual wetlands and entire watersheds (Keddy, (2010). Healthy wetland environment is not only required for normal physiological functioning of wetland birds but it is also prerequisite to resounding functioning of both terrestrial and aquatic ecological setting. This the birds understand very well and therefore associated closely with the area. The wetland birds use the ecosystem for many purposes. The ecological services of wetland go a long way in determining the quality of life the avian derives. Wetland birds' life-cycle might be imbalance in the absence of this unique habitat. The ecosystem interaction of organisms and the physical environment often services rare species of plants or animals, fish for recreational or commercial uses, water purification, recharge of groundwater, flood control, and wilderness areas (National Research Council, 2005). In spite of critical ecological wetlands envi

ronment, they are poorly understood and subjected to abuse use in most developing nations. This attitude could possibly be linked to unimpressive conservation education and recurrent issues of unemployed teeming population of the area which add up to converting any "available land" with water source as target for farming exploitations without thought of the dire consequences. Wetlands have been terribly exploited in this modern day as man quest for maximum exploitation of natural resources grow. Wetlands that are close or not too far from human habitations receive more pounds of abuse uses. Worldwide, the extent of natural wetlands continues to decline as land is

converted to accommodate increasing human populations (Chris, 2000). Rice fields generally are inundated for long periods and often occur in areas where wetland losses have been greatest.

There is no doubt that massive food production has improved human life expectancy. Agricultural activities tremendously enhance human development. Nevertheless, wetland conversion goes with dire ecological consequences. The rate at which wetlands habitat is been loss shows that there is little consideration for ecosystems conservation at the planning and implementation of most farming projects. In fact, the turnaround of wetlands to farmland continues with little or no consideration for biodiversity sustenance.

The vast conversion of many wetlands to agricultural farming and its consequences' on wetland bird species in Rwanda necessitated this research with view to suggesting working plan that will be acceptable to biodiversity/wildlife managers whose aim are conservations of all species and agriculturists whose objectives reclined on global food abundant for universal benefits.

Recognizing that wetland is threatened by urbanization and yet also contributes to the quality of life in cities, it is important that we place greater emphasis on designing the places where we live and work in ways that accommodate the needs of other species and highlights the interdependence between people and the natural world, Success rests in our ability to find "win- win" scenarios in which both people and biodiversity benefit" (Miller, 2008).

Continuous commercial production of rice and high demand of the produce indicates that more wetlands would be converted to rice land against protection of avian species. The continuous dwindling of wetland habitat areas across Huye metropolitan city requires a deep study to ascertain the use and

role of wetland on the abundance and diversity of Gahenerezo wetland Rice Plantation on wild bird.

Study Area

Gahenerezo wetland is located near the Huye Metropolitan Taxi Park, in the Southern Province of Rwanda. The study area is eight (8) hectares in size. The wetland is divided into two parts, four (4) hectares each on the two sides of the tarred road. The rice plantation in Gahenerezo is a wetland irrigated by water from mountains source that was artificially channeled to run along the transect line for irrigation (Plate 1).



Plate 1 : Ground-based view of Rwanyanza Gahenerezo rice plantation, Huye Rwanda

Methodology

Thirteen (13) transect line of (34m x 15m) corresponding to individual farm size allotted to farmer was used. Thus, Simpson's index method of Abundance and Diversity was applied to record sighted birds and analyse the population. Hypotheses were tested using T-test and Randomized Complete Block Design at 0.01 and 0.05 probability. Structured questionnaires were also distributed to rice farmers to source further information on bird sighting with regards to abundance and diversity in the wetland. On the fixed transect the following data were recorded: (a). the total distance travelled along transects. (b). the animals and species to be counted. (c). time taken to walk along transects and (d). the location of the sighting.

Problem Statement

Most wetland habitats in Huye, Southern Province of Rwanda are constantly farmed because of constant guarantee source of water throughout the year. This practice changes the ecological parameters of the area of which the wetland birds relies.

The objectives of the Study

The objective of this research is to determine the effects of rice plantation on bird diversity and abundance in Gahenerezo wetland habitat, Huye.

Research Hypothesis 1

H_0= Wetland conversion for rice plantation **does not affect wildbird abundance and diversity in** Gahenerezo**.**

H_A= Wetland conversion for rice plantation **does not affect wildbird abundance and diversity in** Gahenerezo**.**

Research Hypothesis 2

H_0= There is no significance difference on the abundance of birds in the wetland between morning and afternoon of the days of the study.

H_A= There is significance difference on the abundance of birds in the wetland between morning and afternoon of the days of the study.

Research Hypothesis 3

H_o= There is no difference among distribution of bird species in the transects in Gahenerezo wetland.

H_A= There is difference among distribution of bird species in the transects in Gahenerezo wetland.

Justification of the research

The project will be relevant in establishing environmental threats confronting wetland bird species in the conversion of wetland to rice farmland. In addition, proper knowledge of the role of wetland in avian life cycle will improve biodiversity conservation.

Result and Discussion

TEST OF ABUNDANCE AND DIVERSITY INDICES

Table 1: Simpson's Index of Bird's Species Found in Gahenerezo Rice Plantation

Com-mon name	species	T_1	T_3	T_5	T_7	T_9	T_{11}	T_{13}	Sum	Pi	Pi*Pi
Red-winged black-bird	A. phoe-niceus	3	8	13	16	6	4	6	56	0.538462	0.289941
Blue heron	A. hero-dias	0	4	8	0	0	0	0	12	0.115385	0.013314
Black ibis	P. fal-cinellus	0	3	1	0	0	0	0	4	0.038462	0.001479
Hadada ibis	B. hagedach	0	0	9	0	0	2	3	14	0.134615	0.018121
White ibis	T. aethio-picus	10	0	6	0	0	0	2	18	0.173077	0.029956
Total		13	15	37	16	6	6	11	104		0.352811

Simpson's index = 0.35

Bird	Pi	log Pi	Pi log Pi

Table 2: Shannon-Wiener's Index of wild bird's species in Gahenerezo Wetland

Common	T 1	T 3	T 5	T 7	T 9	T 11	T 13	T 1	T 3	T 5	T 7	T 9	T 11	T 13	T 1	T 3	T 5	T 7	T 9	T 11	T 13
Red-winged	0.23	0.5	0.4	1	1	0.7	0.5	-0.6	-0.3	-0.5	0.0	0.0	-0.2	-0.3	-0.15	-0.15	-0.16	0.000	0.000	-0.12	-0.14
Blue heron	0.0	0.3	0.2	0.0	0	0.0	0.0	0.0	-0.6	-0.7	0.0	0.0	0.0	0.0	0.000	-0.15	-0.14	0.000	0.000	0.000	0.000
Black ibis	0	0.2	0	0.0	0	0	0.0	0.0	-0.7	-1.6	0.0	0.0	0.0	0.0	0.000	-0.14	-0.04	0.000	0.000	0.000	0.000
Hadada ibis	0	0	0.2	0.0	0	0.3	0.3	0.0	0.0	-0.6	0.0	0.0	-0.5	-0.6	0.000	0.000	-0.15	0.000	0.000	-0.16	-0.15
White ibis	0.77	0	0.2	0.0	0	0	0.2	-0.1	0.0	-0.8	0.0	0.0	0.0	-0.7	-0.009	0.000	-0.13	0.000	0.000	0.000	-0.13
Total															-0.23	-0.44	-0.62	0.000	0.000	-0.28	-0.43

From SW index = 0.43

Table 3: Abundance of bird species in each transect during morning and afternoon

Days	Morning	Afternoon	**x-y**	**$(x-y)^2$**
1	24	0	24	576

2	13	0	13	169
3	0	8	-8	64
4	0	12	-12	144
5	11	19	-8	64
Total	48	39	9	1017

At 0.05 significance level, T-tab (2.78) >T-cal (0.25) from this result, there is no significance difference of abundance of birds between morning and afternoon of the days in Gahenerezo wetland.

Table 4: Difference in Distribution of birds species among the transects in Gahenerezo wetland

DAYS	**T1**	**T3**	**T5**	**T7**	**T9**	**T11**	**T13**	**TOTAL**
1	11	5	2	3	1	2	0	24
2	0	2	3	3	1	2	2	13
3	0	1	2	1	1	1	2	8
4	0	3	2	3	1	0	3	12
5	1	1	10	2	1	0	1	16
Total	12	12	19	12	5	5	8	73

Result implies that F-tab (3.18) > F-cal (2.28) at 0.05 levels of significance which mean there is no significance difference among distribution of bird species in the transects in Gahenerezo wetland.

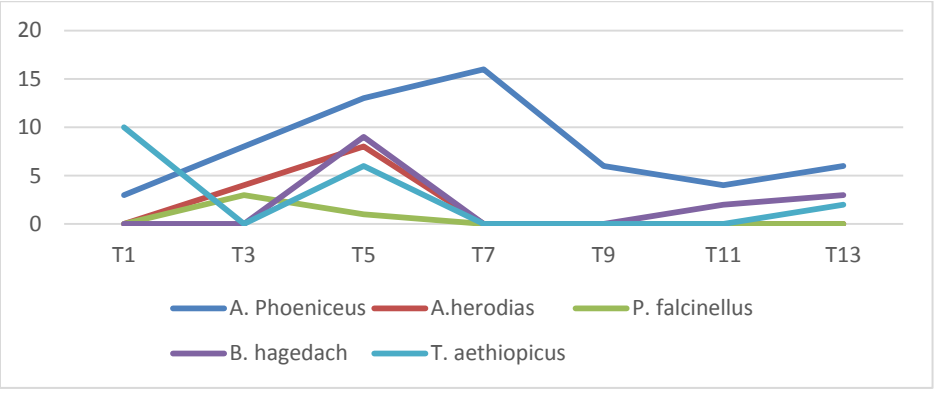

Figure 1: Distribution and abundance of bird's species in each transect

These different feeding mechanisms of the birds have helped us in identifying the reason why those some birds' species were more concentrated in some transects than other. The important part on this chart is the peak of each line which represents the highest point where a particular species is more abundant. For this, Ibises and Great heron peaks are found on transect T3 and T5 while the red-winged blackbird which feeds on cereals T7 and its line remains high along the other transects. From table 3, there was no significance difference in abundance of birds between morning and afternoon of the days in Gahenerezo wetland. This shows that the bird population in the morning and afternoon during the course of this research is relatively similar. Also, there was no significance difference among distribution of bird species in the transects in Gahenerezo wetland as reflected on table 4.

The transect from T_1 up to T_5 are mostly wet and flooded and contains fish ponds and agriculture water dam controller and the transect from T_7 up to T_{13} comprises of well drained rice plantation and grown plantation of local community couple with prey abundance and type in each transects are contributory factors that influence the dominants of particular bird species at a point in time in each transect (Fig 1).

WETLAND RICE PLANTATION ON BIRDS DISTRIBUTION AND ABUNDANCE

1. Habitats Alteration

Mitsch and Gosselink (2000) stated that the global wetland area is generally estimated to be 7- 9 million km^2 or 4-6 percent of the land surface of the Earth. Farming activities is one of the main factors of wetland alteration. Land preparation for rice farming in Gahenerezo alters the natural settings and composition of the biota. Lands are till, turn up and mixed as some of the farming activities. This alters the soil structure, texture and profile which go on to modify specific vegetations distribution, diversity, growth and covers. Continuous flourishing of many wetland birds is correlated to the habitat status. For these reasons, destructive habitat makes wetland a hell for the bird distribution and abundance. Result of table 1 implies low abundance of bird. This could be attributed to wetland habitats alteration as a result of rice farming activities.

Gahenerezo Wetlands unique ecological richness serves as important place for some wetland birds. The interrelationship association of the physical, biotic and the birds components are intrinsically intertwined as essential parts of the whole called wetland ecosystems. Healthy and resourceful habitat is a formidable environment that provides quality and sustains life needs of the dwelling biota. Birds of wetland should be able to access the habitat for their needs with minimal difficulties or ease. Quality bird environment must offer necessities of life such as food, survival (protection) and shelter. Habitat quality is critical to the survival of the aquatic avian. Many birds using wetlands have adapted special features which enable them to feed on rich food sources. Swimming, wading, diving, perching and hovering permit them to feed in wetland areas. Wetlands are very rich in species abundance and diversity and without direct conflict because different species have evolved to use very specific portions of wetlands. (Duncan, 2011).

2. Loss of breeding ground

Undisturbed breeding site is crucial in bird abundance and distribution. Gahenerezo wetland habitat was recorded in the past was to be relevant as a place for initiating courtship or sex mate selection and finalization of mating process in some wetland birds. The height and density of vegetation, frequency and extent of wet patches, the nature and frequency of disturbance, and the gradualness of change in traditionally occupied territories are significant influences on habitat selection (Eglington, 2014). It has also been observed that some wetland species in the study site used the place for identifying playmates and some forms of bird ritualization. Interference in wetland structure as a result of unchecked rice plantation destroys the natural sequential functions of wetland. Nesting within the area was destroyed. Also, brooding and some damaged or broken eggs were seen on some rice plots. Furthermore, wetlands have been a place for rearing of young chicks but, this has become a rare case in Gahenerezo. Chicks were not sighted during the course of this research. This implies that the place is becoming very difficult for rearing of newly hatched chicks.

3. Unfamiliar corridor for migrating birds

Migrant and resident birds interact with agroecosystems in different spatial and temporal ways so land-use changes affect migrant and resident populations diffe-rently (Lima and Zollner 1996). Actually, it is not all wetlands that serve as stop-over for migratory birds. Birds of different flocks' size have been known to temporarily stop on transit at some point for one needs or the other at many wetlands point. However, Gahenerezo wetland has no recent record of this. This might not be unconnected with intense infraction use of the land for farming. It is roundly farmed every year. Gahenerezo is extensive-

ly farmed to the point that it has almost lost all native biodiversity populations. During rice plantation, most of the native zooplankton and phytoplankton are tampered with. From table 2, the diversity of bird in the study area is equally not encouraging. Reason to be adduced for this would include the once familiar environment to migrating wild birds becomes a novel habitat which is strange to the species and at the same time unsupportive of the bird needs because of changes in native plankton composition. This situation affects distribution and abundance of birds in the study site. Ability of wetlands to serves as transit stop-over increases abundance and richness of the avian population. Organization for Economic Co-operation and Development (1996) stated the world may have lost an estimated fifty percent (50%) of its wetlands that existed since 1900.

4. Change in water volume, Flow and Depth

The constant water source which is the basis of attraction to rice farmer in Gahenerezo is also one of the primer factors for bird congregation in the wetland. However, Gahenerezo wetland is locally irrigated by individual farmer. The extensive irrigation and superficial water channeling for farming reduces water volume, flow and depth which are essential factors of water availability for bird utilization. This impacts negatively on abundance and distribution of the birds in Gahenerezo because the water volume, flow availability and depth are distorted. Agricultural expansion and land use change are leading drivers in the global decline of biodiversity (Norris 2008). Water channeling in Gahenerezo has completely distorts, change and or limit the use to which the birds can put the wetland. Wetland birds used water for many purposes apart from drinking which include swimming or diving for food search, exercises and relaxation, escaping from predator or attack and training of young ones. For these reasons, the water volume, depth and flow rate are all im-

portant factors that influence abundance and diversity of the avian species at wetlands.

5. Reduction in source of food, number, size and prey varieties

One in eight bird species is threatened with global extinction (BirdLife International 2010). Reduction in source of food or in the number, size and varieties of prey due to soil turn up or remixing in preparation for planting is a constant recurrence. Rice plantation activities disturbed natural food chains and its richness. The natural vertebrate and invertebrate composition and quantity that are found there in Gahenerezo wetland are badly affected. In an undisturbed wetland setting, there is natural mechanisms for sustain provision of regular and diverse varieties of food source. However, the true situation in Gahenerezo is that rice farming has make food searching and gathering a very tedious exercise for the wetland birds. Wetlands birds that are part of the Gahenerazo ecosystem are therefore negatively affected as rice plantation derail the natural flow of food chain. In reality, converting wetland to farming disorganized the true ecological formation.

6. Resting and Shelters.

Wetland is the transition between aquatic and terrestrial. The ecosystem is unique in the sense that it absorbs shock from the sea and the land. It is a strong absorber of environmental pressures. Vegetation removal during preparation for rice planting, noise from human activities in the field, direct hostility on birds and insecurity displayed by birds in close proximity to man makes Gahenerezo wetland unsuitable for resting and shelters unlike before. Presence of man on farm mostly throughout the day scares birds, therefore reducing the population in Gahenerezo. All these reduce congregation and diversity

as presence of one species attracts another in return as law of nature. Also, presence of scared-crow, sound or drum beating in the wetland makes Gahenerezo unbearable for resting or shelters place for the birds.

7. Gahenerazo wetland pollution

Pollution of any type is known to be fatal to environment. Natural habitats have ways of eliminating naturally generated pollutants. However, when the sources of pollution are man-made and if it goes further to accumulate at high volume it then becomes source of concern for healthy environment. Be that as it may, rice plantation in Gahenerazo wetland involves application of synthetic chemicals such as herbicides, pesticide, insecticide and fertilizers. The identified inorganic fertilizers used in rice plantation are: Diamine Phosphate (DAP), Nitrogen Phosphorus and Potassium (NPK) and Urea. These synthetic chemicals kill, maim and greatly poison the ecological constituents in Gahenerezo. Pollutants such as phosphate ions, ammonia poison, nitrates toxicity (from fertilizer) and heavy metals (from insecticide, pesticide and herbicide) are inimical to environment. Bhattacharyya et al, (2012) stated that the volume of Dinitrogen monoxide (N_2O) in rice field from application of synthetic in comparison to control rice field in four years of study.

Farmers often apply these chemicals during various stages of rice plantation. Many farmers are even proud to display some used containers during this research. The use of insecticides, pesticides, herbicides and inorganic fertilizers are nothing but environment pollutants. At higher level of accumulation, they accumulate and cause soil, water and broadly environmental pollution which go on to reduce bird abundance and distribution.

CONCLUSION

Unabated use of synthetic compounds (herbicide, pesticide and fertilizer), rampant tilling of the soil, erection of scared-crow on farm and other human activities has completely changed the plankton compositions which goes on to destabilized the natural settings of ecological, food, nutrient, energy and water cycles which are necessary combinations for bird healthy environment in the wetland. In a nutshell, most activities of rice farmers in the wetland need to be looked into comprehensively.

From observation on the site, there is blatant disregard for respect of government gazette wetland setbacks, people could be seen farming and encroaching over it without offenders being officially reprimanded.

RECOMMENDATION

In other to achieve and maintain healthy wetland for sustain waterbirds distribution and abundance; it requires effective collaboration and harmonization of interest stakeholders interests such as Rwanda Agricultural Board, Wetland conservationists, Ornithologists and Rwanda Housing Authority.

We therefore suggest more encompassing research of this nature be carried out in most or all the wetlands in the country to further establish effects of wetland rice plantation on wildbirds distribution and abundance in the country as a whole.

Any measure arrived at by different stakeholders should be judiciously implemented through periodical assessment to checkmate and ameliorate bandwagon consequences of wetland misuses.

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THE EFFECT OF NOISE ON TRANSMISSION QUALITY IN OPTICAL FIBRE SUBMARINE COMMUNICATION LINK. (CASE STUDY OF YZERFONTEIN TO LEKKI)

UKAGWU K. J[†]. ANDIKARA J. AZI S. O. & EHINLAFA O. E

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ABSTRACT

The telecommunication industry has recorded lots of break-through in recent time due to bandwidth explosion, especially in optical fibre submarine communication. Due to its higher information carriage capacity, most network providers are embracing it for efficiency, higher Quality of Service (QoS), and a broader carriage capacity. Amidst the successes achieved through the establishment of this medium, there are lots of challenges facing the system which includes: High cost of installation and maintenance and electronic noise. In this work, the link was investigated, taking a case study of one of the Networks from Yzerfontein in southern Africa to Lekki, Lagos by a service provider .It has been discovered that most of the repeaters/amplifiers in the network are not receiving signal at the acceptable range of ±1.5 vendor's specification. This implies that more noise is added to the amplified signal which consequently affects the quality of transmission. The data was collected by connecting an RS232 cable at the F interface of the 1660 SM NE (PFE) to the 1320 CT, Craft Terminal proposed for the Q3 Network Elements which is a standardized network management interface, according to ITU-T recommendations. This research has been able to quantify the cumulative noise figure of the received signals of the various repeaters whose values are above the stated range based on the acquired data.

Key words: Amplifier/Repeaters, Optical-fibre, Q-factors, Signal to Noise Ratio (SNR), Submarine.

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I INTRODUCTION

Over the years, there has been a need to enhance or optimize the quality of communication signal, hence the transition from cable, radio, satellite to Optical fibre (terrestrial and most importantly submarine) communication media. The various media in their capacities served or are still serving their purpose. The later, optical fibre submarine communication system evolved in the quest for high carriage capacity for both voice and data. This medium was established to satisfy the customers' desire for more effective, low cost and accessibility of the system. Here is a list of parameters that was considered systematically to design this medium:

Cities connected by the links: The geographic make up gives the basis for defining transmission distances and the geophysical characteristics required for installation work.

Use of existing structures: Some systems with increased transmission capabilities are installed on existing cables (to reduce civil engineering costs). This additional constraint is important when provisioning the future link.

System capacity: The total information rate transmitted between the different points of the link is duly considered.

Transmission quality: This parameter defines the tolerable error limit of the system (one error represents receiving a 1 for a 0 or vice versa). The quality of transmission of the link is expressed as a bit error rate (BER) or as a transmission quality Q-factor (where Q is expressed in dB). Those characteristics depend on the type of signals to be transmitted (voice, data). Current systems are defined for data transmission. A bit error rate less than e-13 is required according to the G.826 recommendation.

Lifetime: The lifetime of a link is generally more than 25 years. Often equipment becomes obsolete long before reaching this limit (transmission rate, etc). One of the most fascinating thing about submarine communication is the network of the parameters which constitute the system [1]. The role of the repeaters in the submarine optical fibre network systems is very vital as they are placed at specific and constant distances to amplify the weak received signal. It is well known that attenuation increases with increase in distance. So, as the optical signal travel down the fibre cable, it reduces in strength but the repeaters amplify the weak signal as it passes through it. This research is focused on the quality of the signal transmitted (Q-Factor) though, to effectively discourse and investigate this, the architecture of the link is elaborately emphasized and some parameters like signal-noise-ratio (SNR) has been investigated also to gain precision.

1.1 Optical Fibre submarine Communication Systems

The sea environment brings about the peculiarity of the submarine systems as it creates the requirements before and during the links operational life. A submarine cable system is often submerged at great depths, hence cable and equipment must be fabricated to withstand extreme pressures, be hermetic to water ingress and completely isolated electrically from sea water, as well as feature high degrees of reliability because repair operations at sea are inconvenient in terms of cost and maintenance [2]. Installing or repairing of submarine cable system requires highly specialized and experienced personnel and ships. Submarine cables must feature a very strong mechanical resistance, against traction and abrasion [3] – which is provided by armoring and are often buried under the seabed to protect them from trawlers or anchors in areas where there are naval activity.

For instance, submerged repeaters and branching units are designed using the latest technology, such as lasers, optical amplification and wavelength-division multiplexers, with a target of 25 years of reliable operation [4]. Terminal station equipment includes the best from terrestrial systems, plus specially designed transmission equipment that allows transmission distances over 12000 km on an optical fibre without regeneration. In addition, terminal stations increasingly include very state-of-the-art computers and software to enable real-time monitoring of the behavior and performance of whole submarine network.

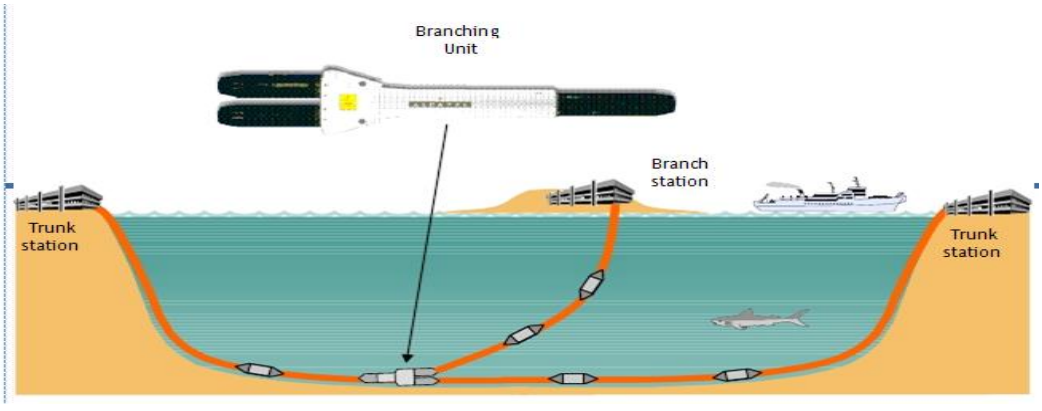

Figure 1: A typical optical submarine network [2].

Branching Unit (BU): Based on the architecture of the submarine network, is often necessary to branch off some of the traffic (and therefore the fibres) to an intermediate station. This splitting of the cable is performed by a branching unit (BU) which provides the various fibre connections and routing of the repeater power feed current between the main cable and the branch. This work is limited to the link connecting Ezerfontein in south Africa and Lekki in Nigeria.

Optical Fibre Submarine Cable

Optical fibers serve as foundation of an optical transmission system because optical signals are transported through them from one point to another. Its advantages of low-loss and very high bandwidth allows high-speed signals to be propagated through a long distance before the amplification is requires [4]. A low-loss optical fiber is fabricated from different materials; the basic raw material being pure silica, is doped with different materials in order to alter the refractive index of optical fiber.

Single Mode Fiber Optic Cable

Single Mode fiber optic cable has a small diametral core that allows only one mode of light to propagate. Because of this, the number of light reflections created as the light passes through the core decreases, lowering attenuation and creating the ability for the signal to travel further.

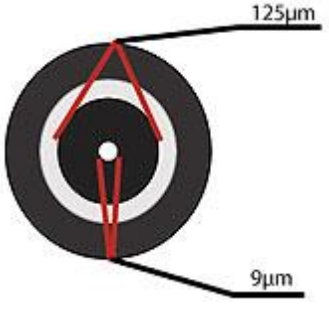

Fig. 2: Single Mode Fibre Cable. [5].

Single Mode fiber is usually 9/125 in construction. This means that the core to cladding diameter ratio is 9 microns to 125 microns.

Repeaters (Amplifiers)

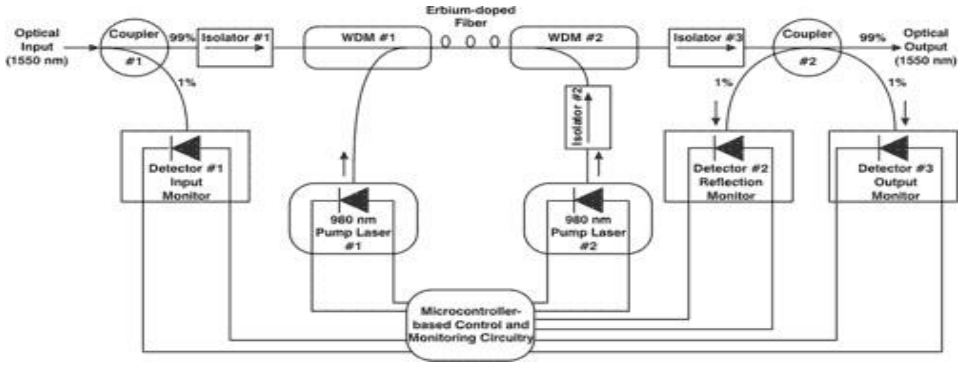

Fig. 3: Optical Repeater [6].

As earlier mentioned, repeaters are very vital in that if it is exempted in the network; the whole set up will be paralyzed. The repeater can be described thus:

Performance designed to match needs of system

Two sizes presently available

Costs strongly dependent on number of fiber pair and performance

Spacing (between repeaters) set for system performance / cost, and typically 50-80km (for recent technologies, 400-600km)

Shorter spacing generally yields higher ultimate capacity

In long (many thousand km) systems, often largest single component network cost.

For point-to-point network, we have the system set-up as in this frame.

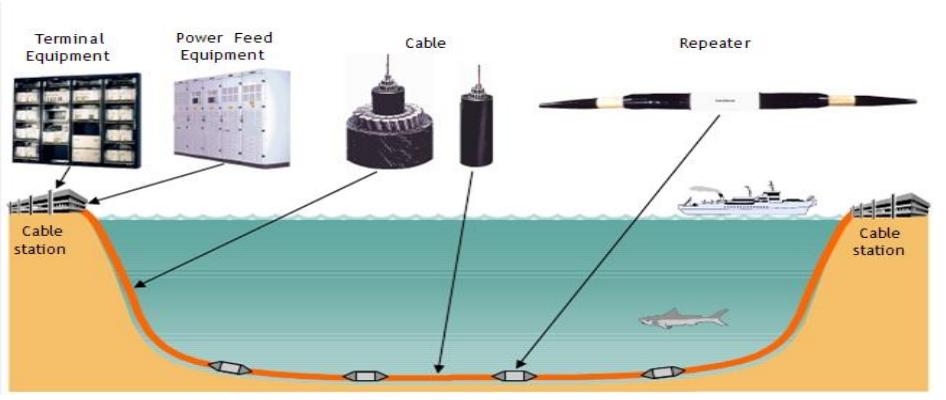

Fig. 4: Point to Point Link [2].

The transmission distance of a fiber-optic communication system has traditionally been limited by fiber attenuation and by fiber distortion. By using all optical repeaters, these problems have been eliminated. These repeaters do not convert the signal into an electrical signal. Because of the high complexity with modern wavelength-division multiplexed signals (including the fact that they had to be installed about once every 64 km), the cost of these repeaters is very high.

The purpose of an optical repeater/amplifier is to restore the signal power level, reduced due to losses during propagation, without any optical to electrical conversion. The general form of an optical amplifier is given in Fig. 3. Most optical amplifiers amplify incident light through the stimulated emission, the same mechanism that is used in lasers, but without the feedback mechanism. The main ingredient is the optical gain realized through the amplifier pumping (electrical or optical) to achieve the population inversion. The optical gain, generally speaking, is not only a function of frequency, but also a function of local beam intensity. To illustrate the basic concepts, we consider the case in which the gain medium is modeled as two-level system, as shown in Fig. 3. The amplification factor G is defined as the ratio of amplifier output Pout and

input Pin powers G = Pout/Pin. The amplification factor can be determined by knowing the dependence of evolution of power through the gain media.

$$\frac{dP}{dz} = gP, \quad g(\omega) = \frac{g0}{1+(\omega-\omega0)^2 x T^2+{}^{P}/_{Ps}} \qquad (1)$$

g is the gain coefficient, g0 is the gain peak value, ω0 is the atomic transition frequency, T2 is the dipole relaxation time (< 1 ps), ω is the optical frequency of incident signal, P is the incident signal power, and PS is the saturation power. In the unsaturated regime (P ≪ PS), the differential equation (1) can be solved by separation of variables to get the following dependence of power P(z) = P(0) exp(gz), so that the amplification factor can be obtained by

$$G(\omega) = \exp[g(\omega)L] \qquad (2)$$

and corresponding full-width at half-maximum (FWHM) bandwidth is determined by

$$\Delta vA = \Delta vg \sqrt{\frac{\ln 2}{\ln({}^{Go}/_{2})}}, \quad Go = \exp(goL), \qquad (3)$$

Where Δvg is the FWHM gain coefficient bandwidth

Branching Unit (BU)

All BU produced in recent time has three terminals. During installation, any of the terminals can be branched off in other to connect more regions based on the structural design.

The fiber cable networks can be switched from the landing station or shore terminal to power the network. This operation is performed using a Power

Feed Equipment (PFE). Wavelenght Division Multiplexing (WDM) technology has also helped in the area of increasing the capacity of the network. This WDM helps in branching off selected wavelengths though on limited basis.

Over the time, it has been recorded that the cost of each BU depends on how complex it is and the number of fiber pairs that can be channeled through it.

The Branching Unit is used in Submarine network system to branch off optical traffic signals to landing stations at the shores of the ocean in order to connect the grid of the country branched to. The features and functions of a branching unit is as highlighted below. But before then, it should be stated that for the case study in question; the submarine communication cable has its landing stations in these countries from Yzerfontein Southern Africa to Lekki Nigeria through the following route;

Namibia, Angola, Republic of Congo, Cameroon, Togo, Nigeria

The landings in Namibia, the DRC, and Togo have provided the first direct connections for these countries to the global submarine cable network [2].

II METHODOLOGY

From the data acquired, the Q-Factor with respect to SNR was calculated using the following equations [7]

Q = (4)

Where SNR= signal to noise ratio and is given as: $\text{SNR} = \frac{\text{Pout}}{\text{KG}} = \frac{\text{Pout}}{\alpha \text{D}}$

Pout= output power, K = number of repeaters, G = repeater Gain,

$\propto$ =attenuation, D = link distance.

ER= Transmission extinction ratio P(1)/P(0) = 0.1

Bf = optical filter bandwidth = 0.4nm

Be= electrical filter bandwidth = 6GHz [2].

From the data, the SNR for all the repeaters is calculated with specific distances and substituted into the Q-factor equation above in other to investigate the quality of transmission of the link. The attenuation is calculated for all the repeaters using the equation for optical:

$\alpha = 10\log (Pin/Pout)$ (8)

The Gain is calculate from the relation:

$$G = \frac{P_{out}}{P_{in}} \quad (9)$$

Having investigated the fiber link under consideration, Table 4 shows the amount of power utilized by the various amplifiers per 60 kilometer and the calculated Gain and Q-factor respectively.

Table 4: Transmitted power used per 60 kilometer by the various amplifiers

SELECTED RE-PEATERS I D	PIN	POUT	POUT/KM	GAIN (dB)	SNR (dB)	Q-FACTOR (dB)
POWER BOASTER	0.00	19.00	0	0.0	0	0
RPT1-S1A-1	1.17	15.56	0.018281	13	0.0136	17.085
RPT2-S1A-2	1.20	15.58	0.01875	12	0.0147	17.062
RPT3-S1A-4	1.53	15.55	0.017969	10	0.017	16.848
RPT4-S1A-5	1.71	15.56	0.026719	09	0.0196	16.741
RPT5-S1C	2.05	15.46	0.021406	07	0.0250	16.562
RPT6-S1C	1.71	15.54	0.014688	09	0.0196	16.742
RPT7-S1C	0.75	15.56	0.01875	20	0.0088	17.429
RPT8-S1C	1.32	15.60	0.01125	11	0.0161	16.97
RPT9-S1I	2.42	16.10	0.020938	06	0.0198	16.334
RPT10-S1I	2.09	15.94	0.024375	07	0.0110	16.507
RPT11-S1I	1.31	15.91	0.023594	12	0.0080	16.959
RPT12-S2A	0.94	15.63	0.014688	16	0.0111	17.255
RPT15-S2A	1.15	15.68	0.014688	13	0.0137	17.089
PREAMPLIFIER	2.40	0.00	0.020625	00	0.0000	0.0000

*RPT-REPEATER

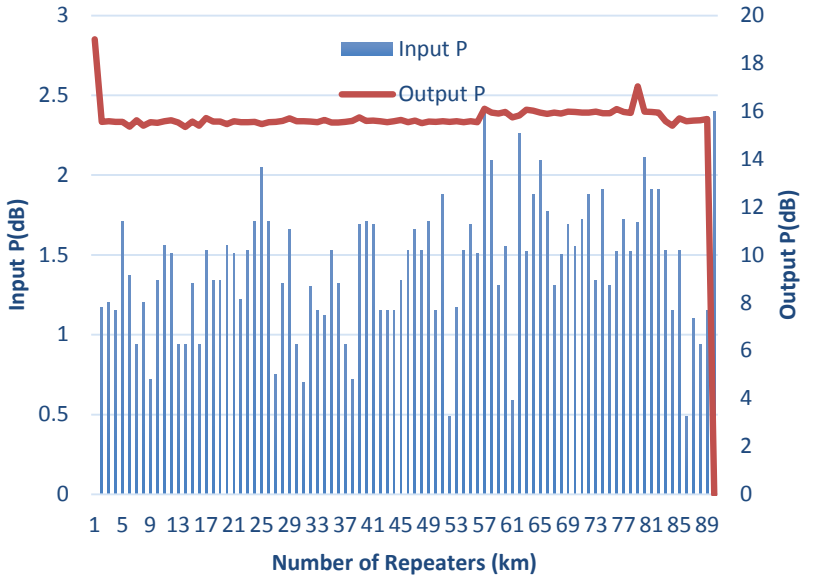

Fig.5 Pout and Pin against Number of Repeaters

Here we find that the output power is almost flat (irrespective of the input value, the output is almost the same), some input power are beyond the 1.5 limit, implying the addition of noise during photodetection and amplification at the EDFA. The implication of the flat output is that the gain of the device is maintained irrespective of the input signal. This informs why the input must be controlled to the acceptable threshold just to limit the multiplicative effect of noise at the EDFA [9].

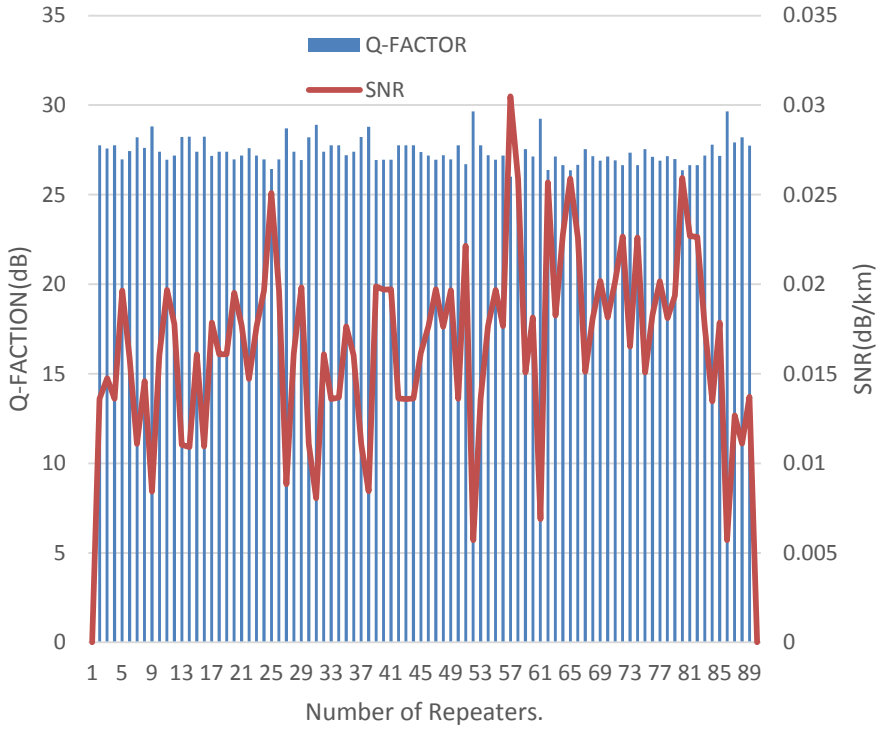

Fig.6: Q-factor, SNR against Number of Repeaters

The sharp spikes explain the inverse relationship between the Q-factor and the SNR. An increase in one reduces the other for the range of values. It is also important to observe that, as the signal propagates, it becomes noisier and the effects become more significant. In this research, from our calculations using 1.50dB as a typical case, an SNR of 0.024dB is the acceptable value. This value is usually selected based on input and output values under review.

III Analysis

From Fig.6, it is seen that a high SNR gives rise to a better Q-Factor and thus implies that the Q-Factor reduces as the SNR tends to unity (the lower the Q-Factor in dB, the better the transmission quality).

The time rate of photon emission and absorption are 1μ second and 10mseconds respectively [8]. This implies that 10% of the laser power is lost to spontaneous emission which becomes the significant noise power (Noise figure). Exactly 50% of the repeaters have their input more than the threshold power, with an average of 0.21dB more which is regarded as noise because the input power is recorded after photodetection. This value constitutes 12% of the input power. Now using the minimum noise figure Fn= 3dB [8], 20% of the output power is actually noise. Cumulative noise Nc = 0.21*44 (number of repeaters with noise above the threshold = 9.24dB. Recall that the gain is flat at 10dB (vendor standard), therefore, at the output of the preamplifier, we will have

P= G * NC =19.24dB. This becomes the recorded power observed at the output of the post-amplifier which implies that 48% of the signal received at the landing station is noise power.

IV Conclusion

It has been established through literature that in the process of amplification in a repeater to raise the input power level, noise is added to the system. This explains why we were able to get more signals received beyond the acceptable value. In general, for better quality of service delivery and efficiency, the bulk of data and voice traffics dumped in our landing stations should be distributed to the homes (FTTH) for utilization. Cumulative effect of noise actually reduces the quality of signals transmitted. This is consistent with [9]. This research work has established that the link has an excess cumulative noise of 9.48dB in the output of the preamplifier which is 48% of the received signal due to a problem in manufacturing. This is possible because most of the APDs are most likely to be set within the operational region in the breakdown knee. It is recommended that a background check be done on the systems to be in-

stalled and the APDs of the EDFA controlled to the required amplification status as the optical signal is incident on it in other to give out an acceptable output.]

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COMPULSORY BASIC WILDLIFE EDUCATION STUDY IN NIGERIA TERTIARY INSTITUTIONS AS TOOL FOR SUSTAIN WILDLIFE CONSERVATION

MUHAMMED SHITTU LAWAL[‡]

ABSTRACT

Alarming rate at which national leader/policy-makers look down on wildlife resources is unbecoming. The paper examined basic understanding of Nigeria educated/elites on wildlife conservation, using Nigeria tertiary students as prospective elites who will form the cream of policies-makers/think-tank of the national on diverse resources management sooner or later. One tertiary institution each was selected from the six Geopolitical zones of Nigeria. One hundred and twenty students each were randomly selected in each school and A total of seven hundred and twenty (720) questionnaires were used. Data were analyzed with frequency table, bar and pie charts. Ninety-five percent (95.0%) of respondents defined wildlife to be only deadly animals that have high tendency to harm. Animal like bird, rat, earthworm, insects, toad/frog and other smaller creatures were not considered as wild species by (98.3%) of the respondents. Nevertheless, (32.5%) of respondents had had interaction with wildlife in the school premises. Also, only 5.0% of respondents claimed to have had negative encounters with wildlife in school. Furthermore, 11.7% of the respondents maintained that wildlife causes disturbances in the school. Just (25.0%) of respondents opined that animal have right of existence. Also, reasons for non tolerance of wild species were given as fear of unpredictable animal behaviour (77.5%); influence of societal indoctrination (89.2%). Lastly, (33.3%) of respondents was ready to support wildlife conservation, (25.0%) were ready to convince others to protect wildlife and (15.8%) agreed that wildlife are useful resources to be protected. Wildlife is an indispensable environment resources that when wisely conserved it will lead to tremendous

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nation development. Sustain wildlife management requires society with better awareness of what conservation stands for. This research establishes inconsequential conservation knowledge among the students who are potential policy makers of tomorrow due to non inclusion of Natural Resources Management in the school general study curriculum. For positive change of attitude towards wildlife conservation and reduction of wildlife loss, Natural Resources Conservation study must be taught as compulsory course in General Study Programme Unit (GES/GNS/GST/GSE) of each institution. This step when adopted will create early awareness in student formative years/ages for better understanding of need for Wildlife conservation as inexhaustible resources.

Keyword: Wildlife conservation education, natural resources management, Nigeria tertiary institutions, wild animals

INTRODUCTION

The natural bionetwork phenomenon which makes man and wildlife incompletely separable is becoming unhealthy towards the biodiversity with the fast rate at which many wild species are being depleted. In the last century man has become a principal agent in the extermination of wild species more than other limiting factors put together.. Habitat alteration and loss couple with increase population of some wild species has turned some of them into metropolitan dwellers. Extreme form of human–wildlife conflict occurs when human lives are lost (Loe and Roskaft, 2014). The irreplaceable roles of wildlife in man survival are not thoroughly understood by majority of the populace. Many species are extinct, some are psychologically disorganised while others are permanently maimed by human activities. The list of hazard which wildlife faces from man is damn too many. The increasing difficulty in tolerating wild species is a cause for concern in Nigeria. High level of intolerance of wildlife increases when there is occurrence or rumour attack of wild species

on man interest. Reprisal attacks on wildlife threaten the survival of the species (Mishra et al. 2003). As man become more expansionists and aggressive in exploring environment due to population explosion and needs so is high tendency of wildlife intolerance. The level of man understanding of wildlife conservation education would invariably determine the degree of co-existence relationship between human and animal. The awareness level is a key to understanding of wildlife behavior and resources. Timely acquisition of conservation knowledge will be tremendous in facilitating wildlife sustainability. With this in mind, this work was carried out with aim of appraising wildlife conservation education knowledge in Nigeria tertiary institutions as tool for sustain conservation of renewable natural resources.

RESULT AND DISCUSSION

INDIVIDUAL DEFINITION OF WILD ANIMALS BY STUDENTS

From table 1, Ninety-five percent (95.0%) of respondents defined wildlife to be only deadly animals that have high tendency to harm. Animal such as bird, rat, ants, insects, toad/frog and many small creatures were not considered as wild species by 98.3% of the respondents. Negative view about wild species is a strong factor for poor definition of what wildlife is truly is (Lawal, 2017). The fact that majority of the students described animals such as Panthera leo (Lion), Loxodonta africana (Elephant), snake, primate, Pandinus imperato (Scorpion), Apis mellifera scutellata (African Honey bees) and Hippopotami amphibious (Hippopotamus) among others as wildlife shows poor understanding of the concept called wildlife. However, Michael and Stephen (2015) stated that improvement on people perception about wildlife in USA was achieved through the North American Model of Wildlife Conservation which was built upon the premise that wildlife is a public trust resource owned by no

one and managed by the government for the benefit of present and future generations.

Table 1: Individual Definition of Wild Animals By Students

ITEMS	YES	%	NO	%
Wildlife are deadly animals	684	95.0	36	5.0
Bird, toad, rat, ants/insect are not wildlife	708	98.3	12	1.7

LEVEL OF INTERACTION WITH WILD ANIMALS

Some of the respondents (32.5%), agreed to have had interaction with wildlife in the school premises. More so, only 5.0% of respondents claimed to have had negative encounters with wildlife in school. According to Estep and Hetts (2010) human-animal interactions can be defined as the degree of relatedness or distance between animal and humans. In this work, there is established gap between the students and wildlife species as shown by the result of Figure 1. The more time people give to understudy living creature the better the possibility of improve interaction between the animal and man. Moreover, the quality of human-animal interaction can have a profound impact on many facets of an animal's physiology and behaviour. Interactions by humans may be neutral, positive or negative in nature (Idrus, 2013).

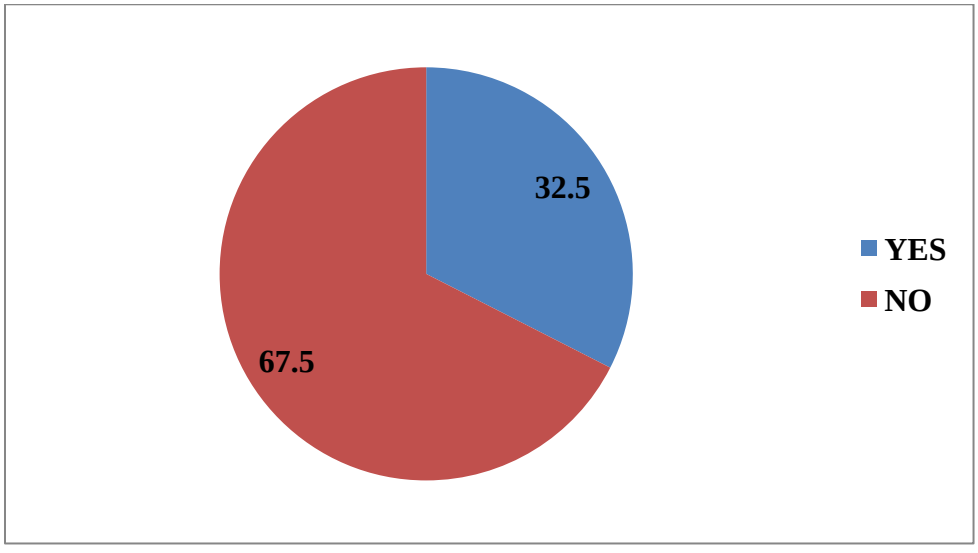

Figure 1: Student Level of Interaction with Wild Animals

INCIDENCES OF WILD ANIMAL DISTURBANCE AT THE SCHOOL PREMISES

Wildlife habitat alteration and or destruction, couple with instinct for survival and or survival by wild animal in the face of ever increasing urban development have forced some to inhabit human populated areas such as educational institution and residential home. Nonetheless, result of figure 2, shows that only 11.7% of the respondents affirmed that wildlife causes disturbances in the school premises. The identified disturbing activities include: bird sound, scavenging and scattering of waste bin. It is to be noted that some students' activities could attracts wildlife, these include but not limited to: unkempt fresh fruit or food, poor disposal of rotten food/fruit, human left-over food, and open waste practice. Also, stream or dam in school premises could serve as attractant to wildlife species.

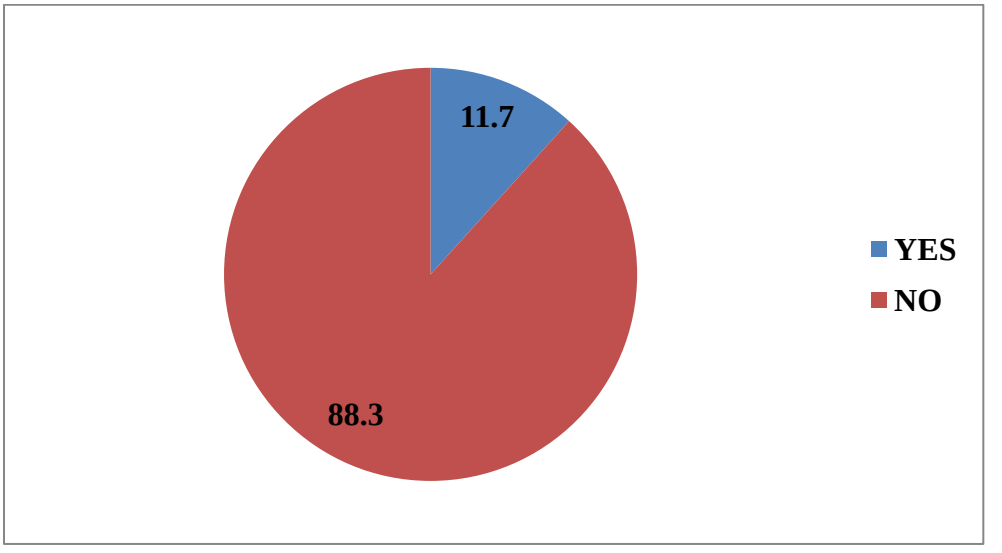

Figure 2: Incidence of Wild Animal Disturbance at the School Premises

WILD ANIMALS HAS RIGHT TO LIFE

On the issues of right to life by wildlife, just 25.0% of respondents were of the opinion that they have right of existence (Figure 3). However, there are national and international laws that protects different status of wildlife. One of these United Nations responsible for protection of wild species is International Union for Conservation of Nature (IUCN) which divides animal status into nine categories: Not Evaluated, Data Deficient, Least Concerned, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild and Extinct. Each status shows the degree to which the animal has suffered. Wildlife in the real sense is part of the larger ecosystem which man himself depends on for survival. The fact that they have life qualifies them to right of living. Indiscriminate catching, maiming and killing in the name of human protection is forbidden. When man becomes unfriendly to wildlife, fear set in. According to Jones (1996), fear is an emotional (psycho-

physiological) response to perceived danger. Fear in man arouse out of self defence or escape which may lead to destructive steps and unnecessary killing of animal. Wild animals try as much as possible to avoid any situation that creates fear which could jeopardise their healthy living. Gray (1987) in his explanation of animal reactions to fear stated that fear is a form of emotional reaction to a stimulus that the animal works upon to terminate, escape from, or avoid. In a nutshell, animal must live and man must exist, both in an amicable environment.

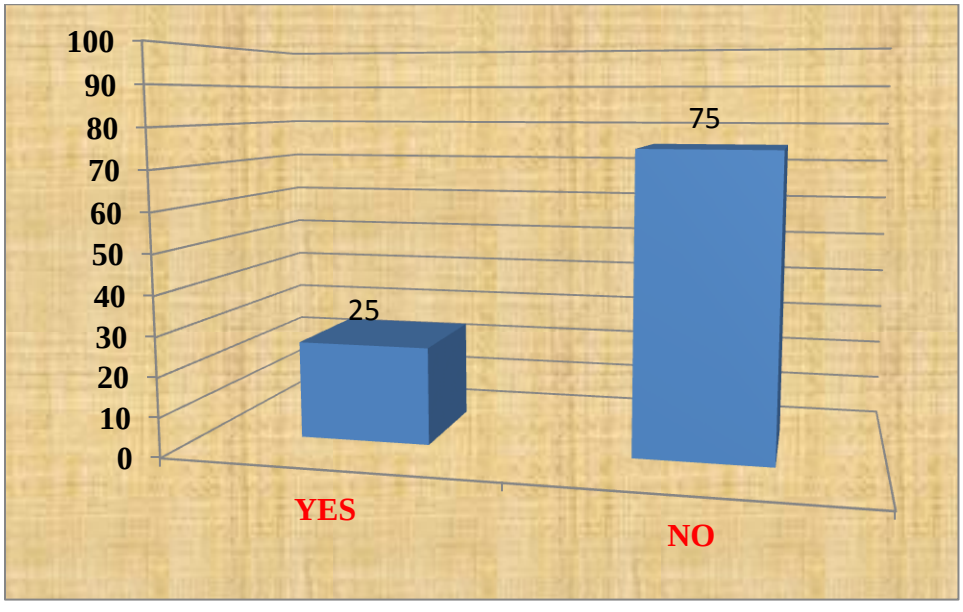

Figure 3: Wild Animals Right of Existence in Tertiary Institution

REASONS FOR NON TOLERANCE OF WILD SPECIES

Wildlife tolerance has a lot to do with the generality of people and the inherited norms plus precedence incidences in particular society. Krithi (2015) stated that tolerance of wildlife varies across the globe. He goes on to say in countries like Sweden and the United States, the sighting of a single wolf can lead to the immediate killing of the animal, regardless of whether it has caused a "problem". From table 2, reasons adduced for non tolerance of wild species by respondents were fear of unpredictable behaviour (77.5%); another reason given by respondents is the influence of folktale/societal indoctrination (89.2%) Compulsory conservation education as a general course at tertiary level will equip and correct many wrong notions on wildlife. It will foster an admiration of wildlife in the mind of students at tender stage of life. Also, right timing wildlife education teaching will be helpful in winning student interest in conservation of natural resources as a whole.

Table 2: Adduced Reasons for Non Tolerance of Wild Species

ITEMS	YES	%	NO	%
Unpredictable wildlife behaviour	558	77.5	162	22.5
Folktale/societal indoctrination	642	89.2	78	10.8

WILDLIFE CONSERVATION EDUCATION

Lastly, on the degree of wildlife conservation education among the students (Table 3**)**, 33.3% of respondents was ready to support wildlife protection, 25.0% were ready to persuade others to protect wildlife and 15.8% agreed that

wildlife are part of ecosystem. Meadows (2011) stated that the concept of public education as a chief objective in Zoological management only came into mainstream in mid- to late 20th century. Disseminating sustain wildlife conservation education to students would boost awareness of issues confronting wild species. Improve understanding of wildlife issues and lead to fervent feelings towards wildlife conservation thus translating to care and love for the animals. This day, conservation education is directed towards parents, teachers and university students for more positive results (Tompson, 1989). The role of scientific knowledge and education has played a significant role in promoting conservation objectives, and a correctly designed conservation education would affect people's attitudes and behavior towards wildlife conservation and protecting their environment (Sterling et al., 2007). This will definitely promote understanding of wildlife and improve quality of environments.

Table 3: Appraisal of Wildlife Conservation Education in the selected School

ITEMS	YES	%	NO	%
Ready to support protection	240	33.3	480	66.7
Ready to persuade others	180	25.0	540	75.0
Wildlife is integral part of ecosystem	114	15.8	606	84.2

CONCLUSION

High literacy level as shown by the educational status of the respondents does not translate to proper understanding of what wildlife represent. There is wide gap between what wildlife actually is and what the students translate wildlife to be. Animals such as Centrochelys sulcata (African spurred tortoise), Musca domestica (housefly), Agama agama (lizard), Papilionoidea (butterfly), Rattus rattus (Black rat), Lumbricus terrestris (earthworm) and Bufo regularis (toad) among others are not seen as wildlife species by students. Erroneously they described wildlife species as brutal, dangerous and unfriendly organisms which have no significant usefulness except to be killed as food or destroy for fear of being attacked. For this reason animal such as: Panthera leo (Lion), Loxodonta africana (Elephant), snake, primate, Pandinus imperato (Scorpion), Apis mellifera scutellata (African Honey bees) and Hippopotami amphibious (Hippopotamus) to mention but few were considered as wildlife. For prevention of present and future loss of wildlife species, there is therefore urgent need for conservation education in all tertiary institutions for positive attitudinal changes towards wild species in Nigeria.

RECOMMENDATION

Natural Resources Conservation study must be taught as compulsory course in General Study Programme Unit (GES/GNS/GST/GSE) of each institution. This step when adopted will create early awareness in student formative years/ages for better understanding of need for Wildlife conservation as inexhaustible resources. Human life is sacrosanct and should be accordingly protected, therefore; collaboration partnership be established between school authority and Game Rangers who are trained in managing wildlife to prevent animal attack on man as is obtained in the western world.

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THE SIGNIFICANCE OF Q-FACTOR AND SIGNAL TO NOISE RATIO (SNR) IN SUBMARINE TRANSMISSION

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ABSTRACT

Modern communication has been revolutionized by the introduction of submarine fibre optic cable system because of their high data transmission capacity, acceptable signal to noise ratio, moderate transmission quality factor (Q-Factor), lower attenuation and efficient gain. In the light of all these breakthrough, some challenges like the introduction of noise at the amplifying devices also confront the medium. This research work has been able to demonstrate that an increase in the Signal to Noise Ratio leads to a reduction in the Q-Factor and consequently a degradation in the transmitted signal. Thus the SNR should be maintained as close to unity as possible. A typical SNR of 0.024dB is most preferred for the network under consideration with an input power of 1.5dB which yield a Q-Factor of 16.70dB.

ey Words: Q-Factor, SNR, Submarine and communication

1. INTRODUCTION

The sea environment is the primary element that makes submarine systems so peculiar, as it creates the requirements before and during the operational life of a link. A submarine cable system is mostly submerged at great depths, hence cable and equipment must withstand extreme pressures, be hermetic to water ingress and electrically isolated from sea water, as well as feature extreme degrees of reliability because repair operations at sea are time-

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consuming and (Agrawal, 2007). Figure 1 describes the submarine link and the components.

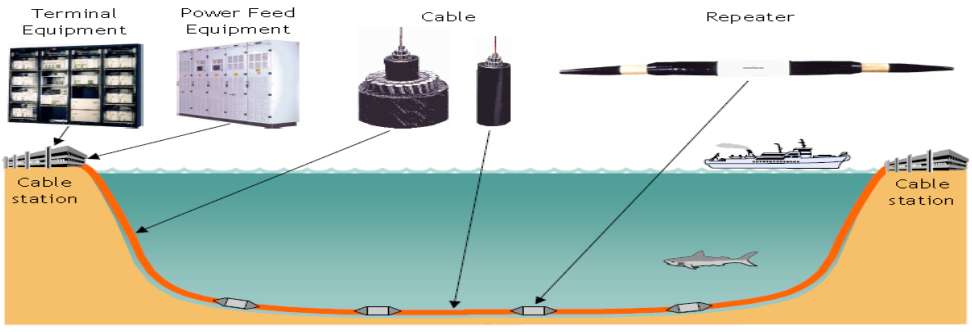


Figure. 1: Submarine network layout (Alcatel, 2010).

Installing or repairing a submarine cable system requires highly specialized ships and experienced personnel. Submarine cables must feature a very strong mechanical resistance against traction and abrasion (ITU-T, 2010), provided by armoring, and they are often buried under the seabed to protect them from trawlers or anchors in areas of intense naval activity. In West Africa, several links exist and they constitute the major communication media to the global fibre link.

Table 1. shows the various submarine links to the West African Cable System (WACS). The various submarine networks in the table give detailed description of the total length, system capacity and date of completion. WACS network under consideration has a total length of 14000km, a capacity of 5.12Tb/s and was completed in 2011.

Table1. Network Operator: cost of installation and total link distance (Simon 2013).

	Sea-com	EASSY	TEAMs	WACS	Main One	GLO1	ACE	SArt	WA-SACE	BRICS
Cost (Millions of USD	650	265	130	650	240	300	700	500	?	?
Length (km)	13,700	10,000	4,500	14,000	7,000	9,500	14,000	9,000	34,000	
Capacity	1.28 Tbs	4.72 Tbs	1.28 Tbs	5.12 Tbs	1.92Tbs	2.5Tbs	5.12 Tbs	12.8 Tbs	40Tbs	12.8 Tbs
Completion	July 2009	July 2010	Sept 2009	Q3 2010	Q2 2010	Q3 2010	Q2 2012	Q2 2013	2014	2014

The layout of the different WACS link is illustrated in Fig. 2. However, this research will focus on the link connecting Yzerfontein in South Africa to Lekki in Nigeria.

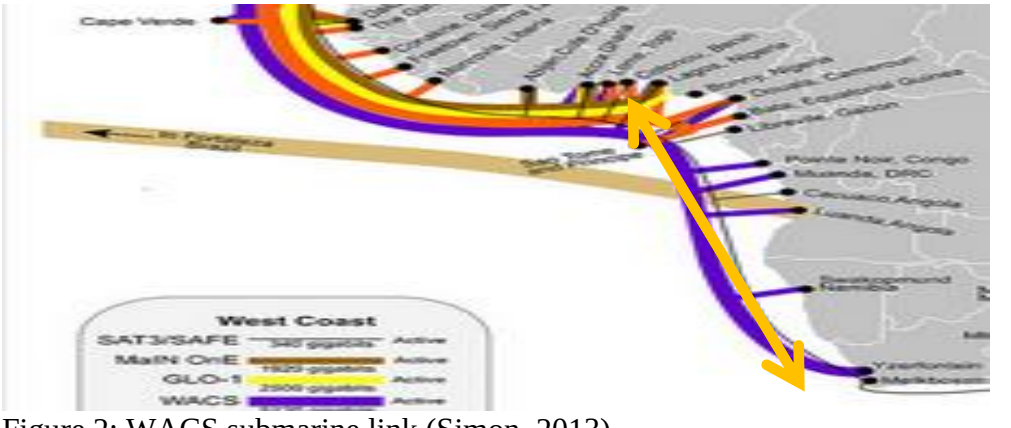


Figure 2: WACS submarine link (Simon, 2013).

The submarine communication network has the following components: cable station, Optical transmitter, optical fibre cable, optical amplifier/repeater and optical receiver. However, when optical signals are transmitted, they get attenuated after a long distance and fades away, hence the need to amplify the degraded signal (Ukagwu et al, 2017). This activity of amplification is carried out at the Repeater/Amplifier unit.

1.1 Optical Repeaters/Amplifiers

In an optical communication, signals from the transmitter are attenuated by the optical fibre as they propagate through it. After some distance, the cumulative loss of signal strength causes the signal to become too weak to be detected, hence the need to restore the signal strength.

Repeaters are very vital in that if it is exempted in the network; the whole set up will be paralyzed (Balaji et al, 2003).This is because the signal cannot be transmitted through a long-haul cable without being amplified. Two sizes currently available are: 1 to 4 fibre pair and 5 to 8 fibre pair (Agilent, 2003).

Each repeater in an optically amplified line contributes some noise to the system, and this noise is amplified in turn by subsequent repeaters. As each repeater compensates (almost exactly) for the loss of the preceding section, the total accumulated noise is approximately equal to noise of one repeater multiplied by the number of repeaters (Alcatel, 2010). As a consequence, there is a gradual increase in noise along the system, which leads to depreciating signal-to-noise ratio as a function of distance.

The optical SNR is approximately proportional to (Jose et al, 2002)

$$\frac{P_{out}}{KG} \approx \frac{P_{out}}{\alpha D}. \quad (1)$$

where, P_{out} and G are the repeater average output power and gain (in linear units), K is the number of repeaters, D is the total system length (in km) and α is the attenuation of line fibre (in dB/km).

According to equation (1), the SNR decreases linearly with the number of amplifiers (at constant gain) and exponentially with the amplifier spacing (at constant number of amplifiers). To obtain a good SNR at the end of the line, it is beneficial to increase the repeater output Power by 20mW (Ukagwu et al, 2017).

The transmitted signal propagates through series of amplifiers over a long-haul and the process of amplification is consequently performed until the signal arrives at the landing station. Several types of amplifiers exist and they include Erbium Doped Fibre Amplifiers, Raman Amplifiers and Semiconductor Amplifiers. The amplifier under consideration in the selected link is the Erbium Doped Fibre Amplifier (EDFA).

1.2 Erbium Doped Fibre Amplifier (EDFAs)

Erbium-doped fibre amplifiers (EDFAs), which were the first Optical Fibre Amplifiers (OFAs) to be developed, are widely used in optical fibre communication systems,, they offer high polarization-independent gain, high output

power, low insertion loss, low noise, and a broad transition near $\lambda = 1.55$ μm (corresponding to the wavelength of minimum loss for silica optical fibres. Pumping is achieved by longitudinally coupling light into the amplifying medium, usually from strained quantum-well InGaAs laser diodes operating at $\lambda_o = 980$ nm. The pump light may be injected in the forward or backward direction, or bi-directionally (Sunil, 2012).

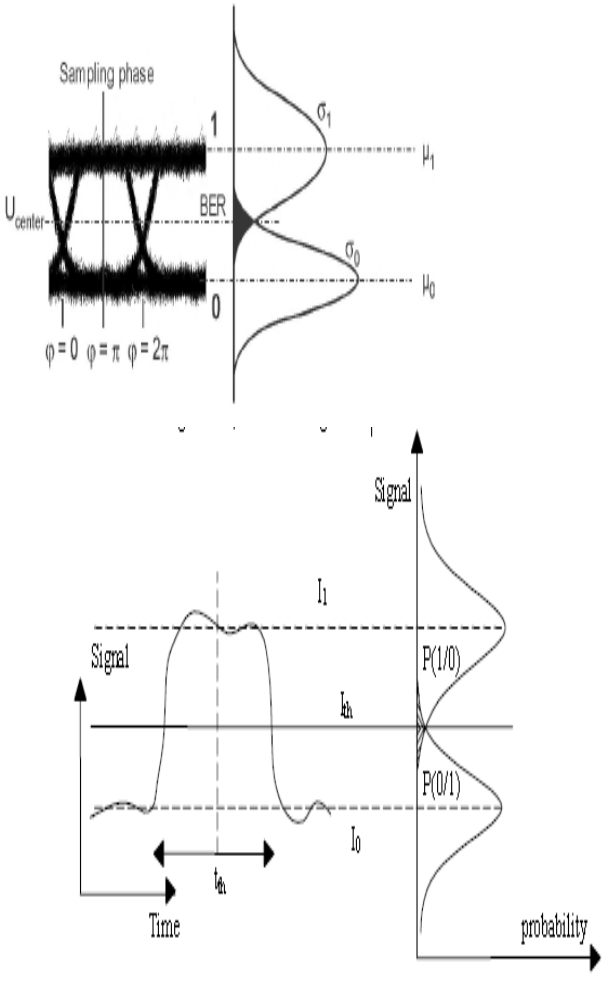
Gains in excess of 50 dB can be achieved in EDFAs with tens of mW of pump power, and signal output powers in excess of 100mW are readily generated. The available bandwidth is $\lambda \approx 40$ nm, corresponding to frequency of $\nu \approx 5.3$ THz, which accommodates the C band. The L band is also readily covered although the optimization parameters of the EDFAs are not the same in the two bands. The large gain and bandwidth offered by these amplifiers make them highly suitable for use in wavelength-division multiplexing (WDM) systems (Agrawal, 2002).

1.3 Transmission quality factor in submarine communication system q-factor theory

To better understand what Q-Factor testing can and cannot do, it is helpful to examine first exactly what Q factor theory is. Q factor measures the quality of a digital transmission signal in terms of its signal-to-noise ratio (SNR). As such, it takes into account physical impairments to the signal, for example, noise, chromatic dispersion and any polarization or non-linear effects – which can degrade the signal and ultimately cause bit errors. In other words, the higher the value of Q-factor the better the SNR and therefore the lower the probability of bit errors.

Specifically, Q-Factor represents the quality of the SNR in the "eye" of a digital signal –the "eye" being the human eye-shaped pattern on an oscilloscope that indicates transmission-system performance. The best place for determining whether a given bit is a "1" or a "0" is the sampling phase with the largest "eye opening." The larger the eye opening, the greater the difference between the mean values of the signal levels for a "1" and a "0". The greater that difference is, the higher the Q-Factor and the better the BER performance.

The goal of the photo receiver is to sample the signal at the decision time t_D and to make a decision concerning its value, as shown in Figure 3 (a) and (b).



(a) (b)

Figure 3: (a) Eye diagram from an Optical spectrum analyzer (OSA) (Agilent, 2003) and (b) Electrical signal after photo detection and conditional Gaussian densities of probability (Cuenit, 2004).

The decision circuit compares the received sampled value to the threshold value I_{th} and forces the bit value to '1' when $I>I_{th}$ and to '0' when $I<I_{th}$. An error occurs when $I>I_{th}$ whereas the value of the bit symbol is 0 and vice versa. We can define the error probability as:

$$\text{Error probability} = p(1) \times p(0|1) + p(0) \times p(1|0) \quad (2)$$

where p(1) and p(0) are the probability to transmit a symbol '1' and '0' respectively. p(0|1) and p(1|0) are the probability of incorrect identification. Assuming the same number of symbols 0 and 1, we have:

P(1)=P(0)=1/2

$$\text{Error probability} = \frac{1}{2} \times [p(0|1) + p(1|0)] \quad (3)$$

Assuming that the distribution of the different sources of noise is Gaussian, we can deduce that the distribution of noise on symbols '1' and '0' is also Gaussian and can be defined by their variancesσ_1^2 and σ_0^2. It is then possible to define the conditional probabilities p(1|0) and p(0|1) (Desurvire, 2002):

$$p(0|1) = \frac{1}{\sigma_1}\sqrt{2\pi}\int_{-\infty}^{I_{TH}} e\frac{(I-I_1)^2}{2S_1^2}dL = \frac{1}{2}erfc\left[\frac{I_1-I_{TH}}{\sigma_1\sqrt{2}}\right]$$

$$p(1|0) = \frac{1}{\sigma_0}\sqrt{2\pi}\int_{-\infty}^{I_{TH}} e\frac{(I-I_0)^2}{2S_0^2}dL = \frac{1}{2}erfc\left[\frac{I_0-I_{TH}}{\sigma_0\sqrt{2}}\right] \quad (4)$$

where erfc is the complementary error function defined by:

$$erfc(x) = \frac{2}{\sqrt{2\pi}}\int_x^{+\infty} e^{-y^2}dy \quad (5)$$

The bit error ratio can then be expressed as:

$$BER = \frac{1}{4} \times \left[erfc\left(\frac{I_1-I_{th}}{\sigma_1\sqrt{2}}\right) + erfc\left(\frac{I_{th}-I_0}{\sigma_0\sqrt{2}}\right)\right] \quad (6)$$

This rate depends on the decision threshold I_{th}. Generally, the decision threshold is chosen to minimize the bit error rate. A good approximation for I_{th} is:

$$\frac{I_1-I_{th}}{\sigma_1} = \frac{I_{th}-I_0}{\sigma_0} \text{ leading to } I_{th} = \frac{\sigma_0 \times I_1 + \sigma_1 \times I_0}{\sigma_0+\sigma_1}$$

We associate the quality factor to the bit error rate through the relationship:

$$BER = \frac{1}{2}erfc\left(\frac{Q}{\sqrt{2}}\right) = \frac{1}{\sqrt{2}}\int_{\frac{Q}{\sqrt{2}}}^{+\infty} e^{-y^2}dy$$

$$BER \approx \frac{e^{-\frac{Q^2}{2}}}{Q\sqrt{2\pi}} \quad (7)$$

This last approximation is valid for Q>3.

And thus, we have the relation:

$$Q = \frac{I_1 - I_0}{\sigma_1 - \sigma_0} \quad (8)$$

Also, the Q-factor relation can be represented as (Jose, 2002)[9]:

$$Q = \quad (9)$$

This equation (9) considers the SNR, the ration between the optical and electrical filter bandwidth and the extinction ratio.

As illustrated above, Fig 3 (a), the width of the curves represents the noise in the signal, hence the lower the noise, the narrower the distribution curve and therefore the smaller the overlap. Indeed, the overlap area on the distribution curves is what determines the BER, for that is where the receiver has a greater chance of interpreting a '1' as a '0' and vice versa, misinterpretations that produce bit errors.

However, that overlap area also is the section that deviates from true Gaussian or normal signal distribution, primarily because of transmission impairments and measurement inaccuracies. Hence, this deviation from the theoretical leads to the inaccuracies in estimating BER. Various ITU-T work/study groups (Agilent, 2003) are trying to determine how to extrapolate the distribution curves more accurately, so as to predict the extent of this deviation more accurately and make the BER estimation more accurate. Unfortunately, until they succeed, network operators and NEM installers cannot be certain their Q-Factor measurements are producing accurate BER estimates.

If the estimated BER is inaccurate and the decisions based on it include replacing cards or postponing testing, then this will result in significant and unnecessary costs and delays in turning up new revenue earning services – the two things operators most want to avoid.

Adding to the uncertainty of what is actually measured in the Q-Factor approach are the questions about how to measure Q factor. There are various ways to measure Q factor today, but the two most common ones are the voltage-histogram method and the variable optical-threshold method but in this

research, it was calculated using equation (9).The first technique (Figure 4) estimates Q factor by using a digital sampling scope to measure both voltage histograms at the center of the eye diagram and the standard deviation of the noise at both signal levels (Agilent, 2003).

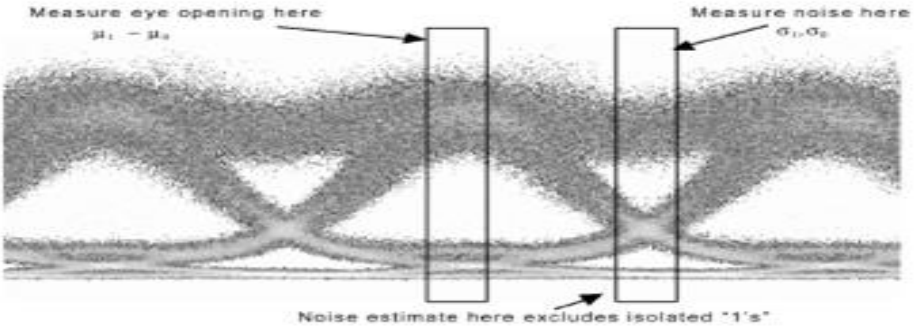


Figure 4: Voltage Histogram (Agilent, 2003).

One of its limitations is the fact that the sampling rate of the scope allows only a small portion of the high bit rate to be sampled. For example, when used to measure a 10-Gbps signal, a scope with a sampling rate of 1M/sample(s) can sample only one bit out of every 100,000 bits, meaning the Q-Factor measurement is based only on a very small portion of the data stream. To make matters worse, the front end of the scope adds noise that can distort the real noise value and thus significantly skew the Q-Factor measurement.

Finally, the voltage-histogram method does not take into account the effects of inter-symbol interference (ISI), or dispersion, which causes pulses to spread out so they appear in adjacent time slots. Because ISI effects can obviously broaden the estimated noise values, they can further skew the Q-Factor measurement. Although network operators and NEM installers can use a specific 1010 pattern to eliminate the ISI, they typically test their systems with PRBSs (pseudo-random bit streams) that closely approximate live traffic. Consequently, ISI effects, along with the other limitations mentioned earlier, make the voltage-histogram method a less-than-ideal choice for measuring Q-Factor – and for calculating that critical BER – in real transmission systems.

Another problem of Q-factor measurement is test equipment. At first glance, the variable-decision-threshold method of Q-Factor measurement would seem

to solve the problem of reducing the time needed to make BER measurements on very-low-BER systems. Unfortunately, it cannot reliably replace the long-term BER measurement for all applications (Sunil, 2012). Until test set receiver requirements are standardized, the incompatibility between different test equipment will produce varied results. To clarify, if the NEM installers measure Q factor with one receiver and a service provider measures it with another receiver, they may get different results. Consequently, the use of different Q factor test sets to calculate the BER will result in different BER values.

Unfortunately, technicians do not have the necessary skills to make accurate Q-Factor measurements, even without compensation techniques or optical channel filters being considered. Such tasks require experienced engineers, a fact that further increases the cost of Q-Factor testing (Agilent, 2003).

1.4 The Role of Q-Factor.

In spite of the limitations of Q-Factor testing as a way to estimate BER in transmission systems, it can play an important role in manufacturing operations. For example, a manufacturer obtains greater Q-Factor accuracy by using "golden" transmitters and receivers, and calibrated equipment that takes into account the noise contributions and other limitations of test receivers. If there is any doubt as to the accuracy of the Q-Factor measurement, the manufacturer simply can substitute the "golden" receiver for the test receiver and then check the results.

Another application (Figure 5) that lends itself to Q-Factor testing is optical fibre submarine cable systems. Measurement techniques that have proven to be adequate during the development process are likely to verify the interface specifications for the amplified sections, which obviously do not represent the entire transmission link. Such indirect parameters include Q factor and optical SNR and accumulated chromatic dispersion. The results, when included as part of the full commissioning tests over the required stability period, can be useful as reference data for future operation, maintenance and repair of the system.

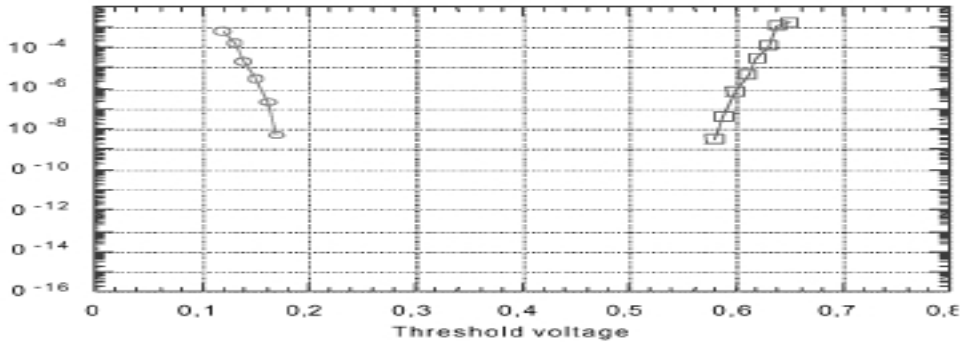


Figure 5: BER measurement. (Agilent, 2003).

1.5 Signal-To-Noise Ratio (SNR)

There is no universal definition of SNR, but for this report a convention will be adopted to for electrical and optical SNRs. The reason for this is to eliminate a common source of confusion, and to ultimately enable the addition of noise distributions from different sources on an apples-to-apples basis. The optical SNR (oSNR) and electrical SNR (eSNR) are defined as (Robert, 2004):

$$\text{oSNR} \equiv \frac{\text{Average Signal Power}}{\text{Optical Noise Power}} = \frac{\text{I optical}}{\text{S optical}}$$

$$\text{eSNR} \equiv \frac{\text{Average Sinal Voltage}}{\text{RMS Noise Voltage}} = \frac{\text{V electrical signal}}{\text{S electricalsignal}} \quad (10)$$

An example of the eSNR would be with respect to the signal and noise at the input of the digital decision circuit (DDC). It is important to make a distinction between electrical and optical SNRs. To convert an eSNR to an oSNR-like value, the power-equivalent SNR value is calculated:

$$\text{eSNR} \; \alpha \; \frac{\text{Average Sinal Voltage}}{\text{RMS Noise Voltage}} = \frac{(\text{V electrical signal})^2}{(\text{S electricalsignal})^2} \quad (11)$$

One must also be careful when making measurements where a voltage represents an optical signal. In this case

$$\text{oSNR} \; \alpha \; \frac{\text{Average Signal Power}}{\text{Optical Noise Power}} = \frac{(\text{I optical})^2}{(\text{S optical})^2} \quad (12)$$

2. METHODOLOGY

The internal parameter is centered on repeaters mostly. The network architecture is designed in such a way that the signal does not escape from the channel either from the transmitter or the receiver. The measured data consists of the optical power sent from the transmitter's output to the input of the repeater. The signal attenuates as it propagates down the fibre but is amplified at the repeater. The repeater is also known as optical amplifier with the recent technology focused on erbium doped fibre amplifiers (EDFA). This technology records minimal dispersion and hence low attenuation. The PFE has computer interface and thus compatible with PCs. Figure 6 shows how the serial cable can be used to connected the submarine network element.

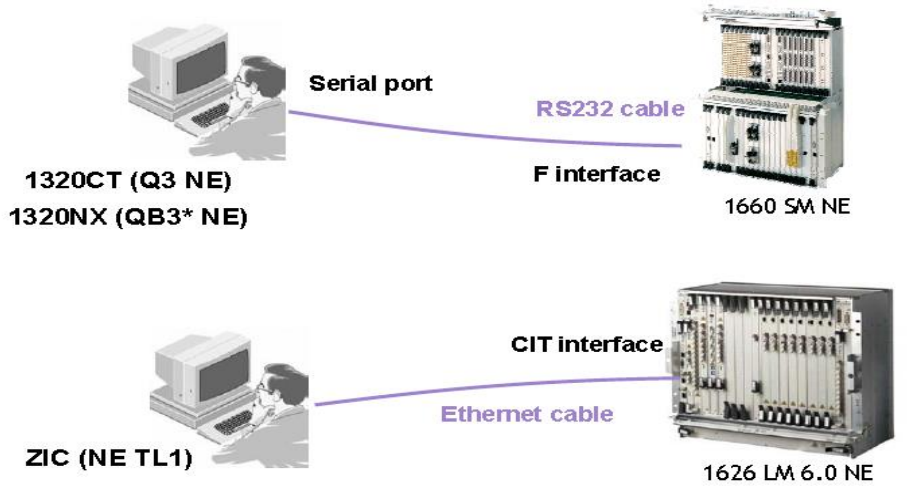


Figure 6: Data acquisition method (Alcatel, 2010).

The TMN is structured in layers, which includes: Element Management Layer (EML) and Network Management Layer (NML) to manage the network element configuration, alarms and performance. The stages below explain the data acquisition procedures.

Stage 1: The RS232 cable was connected at the F interface of the 1660 SM NE (PFE) to the 1320 CT, Craft Terminal proposed for the Q3 Network Elements. Q3 is a standardized network management interface, according to ITU-T recommendations. It provides the necessary local operation and maintenance functionality.

The **IOO** (Internet Order Online) is an open interface that exports Alarm Data, Performance Monitoring Data, NE Directory Data and NE Remote Inventory Data. It also exports the remote inventory data of the NEs managed through ASCII (American Standard Code for Information Interchange) interface via TCP/IP (Transmission Control Protocol/Internet Protocol).

1350 OMS - SN displays Network measurements and performances management. From this display, Acquisition of repeater measurements (input and output optical power) and alarm generation on threshold crossings are made possible.

Stage 2: From the OMS1350, proceeded to GUI (Graphics User Interface) Desktop display. This window contains a menu, a tool bar, a status bar, 3 panels (the tree explorer, the thumbnail view and a console) and a desktop displaying the different views of the application (Network, Fibre Pair, Line, Optical, Power). This is shown in Figure 7.

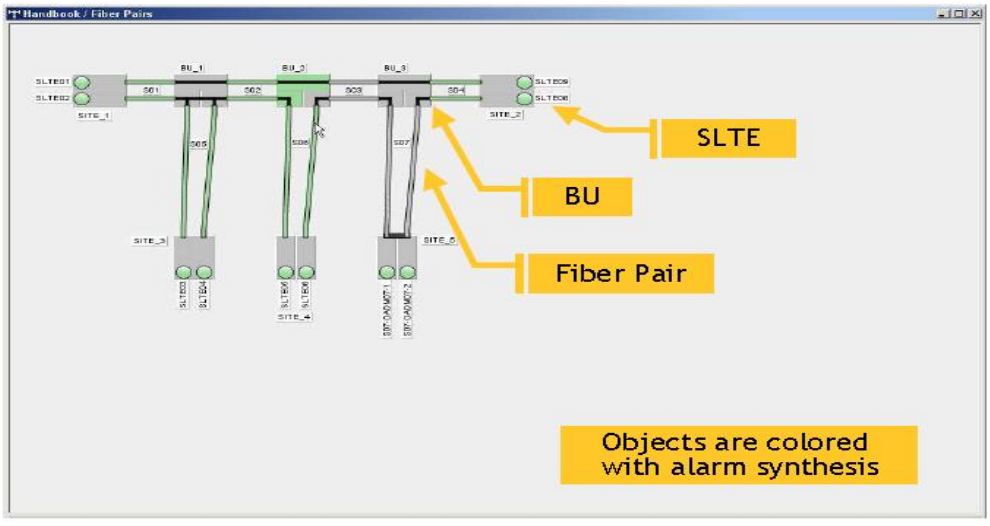


Figure 7: Fibre Pair View

Stage 3: Go to Fibre Pair Optical Path view, the data is displayed as shown Figure 8.

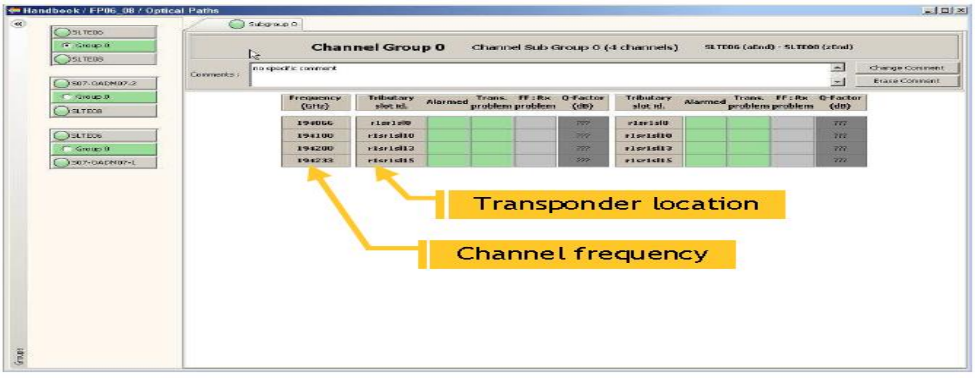
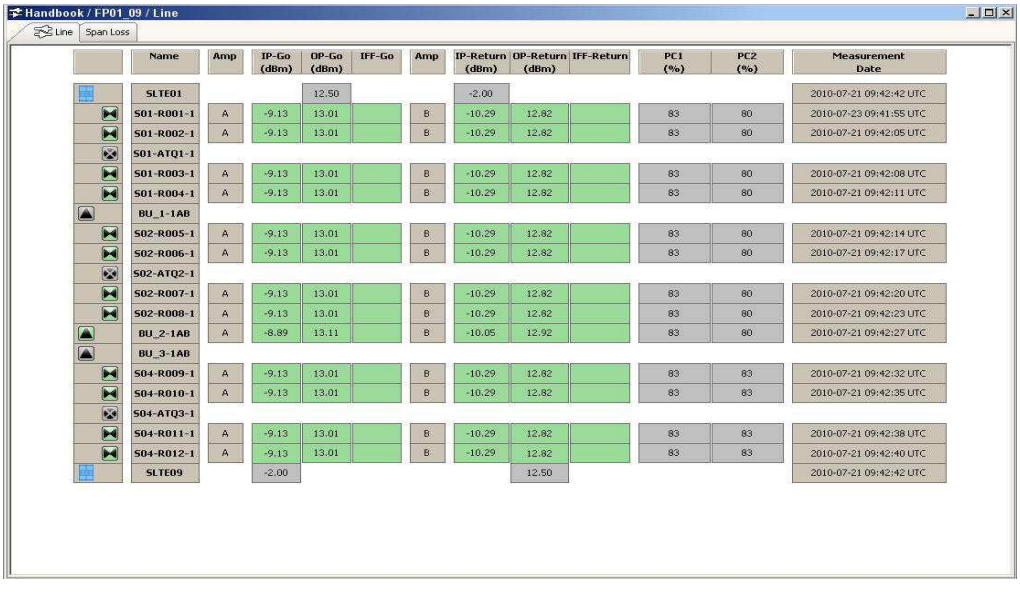


Figure 8: Optical path view.

At the right side an optical channel table of the selected group displays optical path information at either end of the optical path (channel frequency, protection status, tributary identifier, cable fault indication and Q-Factors).

Stage 4: Proceed to Line view to get the display in Figure 9.



	Name	Amp	IP-Go (dBm)	OP-Go (dBm)	IFF-Go	Amp	IP-Return (dBm)	OP-Return (dBm)	IFF-Return	PC1 (%)	PC2 (%)	Measurement Date
	SLTE01			12.50			-2.00					2010-07-21 09:42:42 UTC
	S01-R001-1	A	-9.13	13.01		B	-10.29	12.82		83	80	2010-07-23 09:41:55 UTC
	S01-R002-1	A	-9.13	13.01		B	-10.29	12.82		83	80	2010-07-21 09:42:05 UTC
	S01-ATQ1-1											
	S01-R003-1	A	-9.13	13.01		B	-10.29	12.82		83	80	2010-07-21 09:42:08 UTC
	S01-R004-1	A	-9.13	13.01		B	-10.29	12.82		83	80	2010-07-21 09:42:11 UTC
	BU_1-1AB											
	S02-R005-1	A	-9.13	13.01		B	-10.29	12.82		83	80	2010-07-21 09:42:14 UTC
	S02-R006-1	A	-9.13	13.01		B	-10.29	12.82		83	80	2010-07-21 09:42:17 UTC
	S02-ATQ2-1											
	S02-R007-1	A	-9.13	13.01		B	-10.29	12.82		83	80	2010-07-21 09:42:20 UTC
	S02-R008-1	A	-9.13	13.01		B	-10.29	12.82		83	80	2010-07-21 09:42:23 UTC
	BU_2-1AB	A	-8.89	13.11		B	-10.05	12.92		83	80	2010-07-21 09:42:27 UTC
	BU_3-1AB											
	S04-R009-1	A	-9.13	13.01		B	-10.29	12.82		83	83	2010-07-21 09:42:32 UTC
	S04-R010-1	A	-9.13	13.01		B	-10.29	12.82		83	83	2010-07-21 09:42:35 UTC
	S04-ATQ3-1											
	S04-R011-1	A	-9.13	13.01		B	-10.29	12.82		83	83	2010-07-21 09:42:38 UTC
	S04-R012-1	A	-9.13	13.01		B	-10.29	12.82		83	83	2010-07-21 09:42:40 UTC
	SLTE09		-2.00					12.50				2010-07-21 09:42:42 UTC

Figure 9: Optical line view

The Line View shows the submerged Line Equipment. It allows performing measurements on Repeaters and Bus. From this display, the data is downloaded and recorded.

Once this is successfully achieved, we go to output signal folder, thereafter the output power and repeater. The details of the transmitted power from the PFE to the repeaters are displayed on the computer with time stamps on them as we will see in the data table. This process was repeated once every year for two years due to limited access to the PFE base station. The various repeaters are placed at specific distances apart and the activities there in are recorded through this process.

From Yzerfontein South Africa to Nigeria is an optical fibre of length 5608km buried under water to transmit and share data between the two locations. The link has several branching unit branching units which branches off the signal to the landing stations of the neighboring countries with the sole interest of connecting their national grid. The signal is branched off at Angola, Namibia, Congo, Cameroon, Ivory Coast, Congo DR, Nigeria and so on but the link is between Yzerfontein in South Africa to Sexial in Portugal with a total length of 11378km. But the section under consideration (Yzerfontein to Lekki) has a length of 5608km.

3. RESULTS

There are some basic factors responsible for receiving effectively transmitted signal at the receiver of the landing station. Modern fibre cable is designed to accommodate a minimum attenuation of 0.2dB/km. The implication is that optical signals can travel a longer distance before requiring amplification. With due consideration to our link of study, a typical of 64km distance is traveled before amplification. Since amplification is a necessity, EDFA amongst many amplifiers was considered to be the most effective in terms of Gain, SNR, compatibility with WDM technology and minimum attenuation amongst other characteristics to be used as an optical amplifier. Ideally, repeater-less systems or network gives a better Q-factor than point-to-point repeater network (Sunil, 2012). So far, the transmission distance lies within the amplification range; hence, effective transmission for longer distances requires optical amplifiers.

Recall that the transmission quality (Q-factor or simply Q) as defined earlier in equation (9) is giving by:

Q = ,

where SNR ⇒ Signal to Noise Ratio, ER ⇒ Extinction Ratio, Be and Bf⇒Optical and Electrical filter Bandwidth respectively.

Recall also that from (1) SNR is giving by:

$$\text{SNR} = \frac{\text{Pout}}{\text{KG}} = \frac{\text{Pout}}{\alpha \text{D}}$$

where Pout ⇒ Output power, K ⇒Number of Repeater , G ⇒ System Gain, D ⇒Repeater spacing and α ⇒ Attenuation which is represented as:

$$\alpha = 10\log(\frac{\text{P}_{\text{out}}}{\text{P}_{\text{in}}}) \qquad (13)$$

The data acquired from the link under consideration is as presented in Table 2. Some of the repeaters are deliberately omitted just to shorten the table but are capture in Figure 10.

Table 4.1 Data calculated from the acquired input and output powers

S/N	REPEATER ID	P_{IN} (dB)	P_{OUT} (dB)	SNR (dB)	Q-FACTOR (dB)
	SLT2NYZF	0	19	0	0
1	S1A-R1A01-2	1.17	15.56	0.021634	17.08547
2	S1A-R1A02-2	1.2	15.58	0.021865	17.06242
3	S1A-R1A03-2	1.15	15.56	0.021491	17.09989
11	S1A-R1A11-2	**1.51**	15.63	0.024061	16.85453
12	S1A-R1A12-2	0.94	15.53	0.019922	17.26449
13	S1A-R1A13-2	0.94	15.35	0.019773	17.28076
14	S1A-R1A14-2	1.32	15.57	0.0227	16.98098

15	S1A-R1A15-2	0.94	15.4	0.019814	17.27622
16	S1A-R1A16-2	1.53	15.72	0.024277	16.83516
17	S1A-R1A17-2	1.34	15.57	0.022839	16.96771
18	S1A-R1A18-2	1.34	15.57	0.022839	16.96771
19	S1A-R1A19-2	**1.56**	15.46	0.024251	16.83747
20	S1A-R1A20-2	**1.51**	15.59	0.024026	16.85771
21	S1A-R1A21-2	1.22	15.54	0.021972	17.05177
22	S1A-R1A22-2	**1.53**	15.55	0.024127	16.84861
23	S1A-R1A23-2	**1.71**	15.56	0.025352	16.74111
54	S1E-R1E05-2	**1.69**	15.58	0.025235	16.75111
55	S1E-R1E06-2	**1.51**	15.55	0.023991	16.8609
56	S1I-R1I01-2	**2.42**	16.1	0.030566	16.33493
57	S1I-R1I02-2	**2.09**	15.94	0.028227	16.50777
58	S1I-R1I03-2	1.31	15.91	0.022925	16.95963
59	S1I-R1I04-2	**1.55**	15.97	0.024634	16.8035
60	S1I-R1I05-2	**0.59**	15.74	0.017245	17.57784
61	S1I-R1I06-2	**2.26**	15.82	0.02925	16.43053
62	S1I-R1I07-2	**1.52**	16.06	0.024508	16.8146
63	S1I-R1I08-2	**1.88**	16.03	0.02691	16.61159
64	S1I-R1I09-2	**2.09**	15.95	0.028236	16.50708
70	S1I-R1I15-2	**1.72**	15.94	0.025757	16.70663
71	S1I-R1I16-2	**1.88**	15.95	0.026838	16.61738
72	S1I-R1I17-2	1.34	15.99	0.023204	16.93335
79	S1K-R1K07-2	**2.11**	15.98	0.028396	16.49482
80	S1K-R1K08-2	**1.91**	15.97	0.027056	16.5998

87	S2A-R2A04-2	0.94	15.63	0.020004	17.25551
88	S2A-R2A05-2	1.15	15.68	0.021593	17.08961
89	SLT2SLKI	**2.4**	0	0	0

4. DISCUSSION/ANALYSIS

SNR is one of the most important parameters which define the transmission quality of a signal. Because it is not possible to achieved an SNR of unity, devices are built to maintain a range of values of SNR or as close to unity as possible for an acceptable value of Q-factor. In most cases, the lower the SNR, the Higher the quality of transmission for a given ratio of the square root of the Optical and Electrical filter bandwidths, wavelength and repeater spacing (Mohammed, 2007). Figure 10 is typical of 1550nm wavelength, 64km repeater spacing and a range of SNR values. The plot of Q-Factor and SNR against the number of repeaters as shown in Fig. 10 illustrates the inverse relationship between the two parameters. Hence, the need to maintain their values at an acceptable limit at the various repeaters/amplifiers for effective transmission of signal.

The sharp spikes explain the inverse relationship between the Q-factor and the SNR. An increase in one reduces the other for the range of values. It is also important to observe that, as the signal propagates, it becomes noisier and the effects become more significant. In this research, from our calculations using 1.50dB as a typical case, an SNR of 0.024dB is the acceptable value. This value is usually selected based on input and output values under review.

5. CONCLUSION

Optical Fibre Submarine System is indeed one of the most effective means to transmit optical signals in telecommunication. This is because, even though the signal becomes very weak, it can be recovered to almost the initial value.

The acquired data was used to evaluate the transmission quality (Q-Factor) with respect to SNR and it was observed that an increase as in SNR results to a reduction in Q-factor and vice versa. Hence there is a need to maintain an

SNR close to unity as possible in other to effectively transmit signal with low noise and moderate quality of transmission.

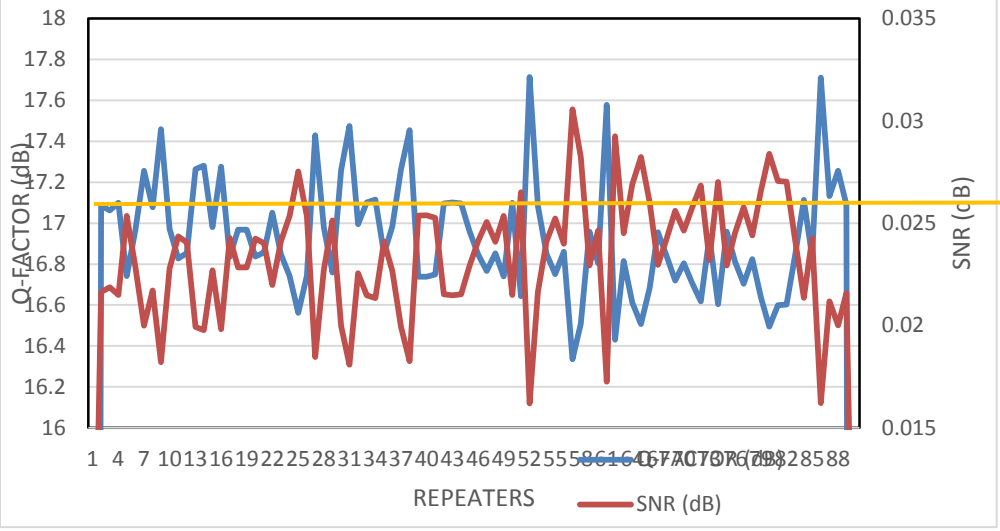


Figure 10: Q-Factor and SNR against number of repeaters.

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ELECTRONIC TECHNOLOGY LITERACY AND PERFORMANCE OF ELECTIONS IN SELECTED STATES IN NIGERIA

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ABSTRACT

Before the adoption of electronic voting technology in 2011, Nigeria's elections were always widely disputed and at times led to post-election violence since her return to democracy in 1999. Such discord was faced in all the three general elections of 1999, 2003 and 2007. According to every post-election technology analysis, electoral disputes were exacerbated by the manual methods exclusively used for the election process. This means the new technology that Nigeria intends maintain for subsequent or future elections was meant redeem the country's electoral credibility. Nonetheless, electoral performance of such potentially redemptive technology reform could not overstated especially its user technicality in a country hi-tech literacy could not be guaranteed. In that case, it was imperative to assess the impact of electronic technology literacy on performance of elections considering the knowledge gap perceived in previous research on Nigeria's electoral automation. For purpose of more recent and exhaustive analysis, the study was limited to the 2015 general elections and six states of Bauchi, Edo, Enugu, Kaduna, Lagos and Niger, fairly selected from the six Zones of the country, respectively. A quantitative and qualitative approach was adopted for the research methodology designed to collect and analyse data from a sample of 265 respondents selected across the six States. The study indicates that performance of the 2015 general elections was highly rated in most of Nigeria at $\bar{x}$= 3.34; s= 1.11. The study further shows that this was partly significantly attributed to a moderate

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electronic technology knowhow ($\bar{x}$= 3.20; s= 1.15) of which administrability of the technology predicted 93.6%, poll workers' competencies predicted 94.3% and electorate technology interface predicted 92.8% of electoral performance. It was concluded that increase in the level of electronic technology literacy would lead to increase in election performance. The reverse was true. As such it was recommended that stakeholders such as INEC and SIEC should adopt several strategies to maintain and/or develop on people literacy of the new technology for better performance of subsequent elections.

Key Words: Electronic voting technology, Election performance, Technology literacy, Poll workers' technology literacy, Electorate technology literacy, Electronic technology

INTRODUCTION

1.1 Background to the Study

Election automation is a recent electoral reform in contemporary democracy. It is one of the latest national policy applications of information technology (IT) that has since history evolved through four successive phases. The current phase is the fourth and most recent of IT evolution that ushered in development of modern computers since the 1940s (Bellis, 2000; Minker, 1998). This phase was preceded by three phases of IT development, beginning with the pre-mechanical phase of 3000 BC– 1450 AD, mechanical phase of 1450-1840, and then the electromechanical phase of 1840–1940 (Butler, 2012). In the current IT phase, computer technology was first used in the 1952 US presidential elections merely for results tabulation, and widely adopted for greater electoral purposes in the 1970s and 1980s in the United States itself, some Asian, South American and European countries (Laanela, Green & Alves, 2016). The technology was since the 1990s consistently upgraded to more advanced versions such as Direct Recording Electronic voting (DREV) in the US and internet voting in countries like New Zealand (Herb, 2005; Hillygus, 2011).

In Africa, such hi-tech progresses are yet to be achieved because electronic voting technology is largely still in its infancy (Laanela et al, 2016). Mainly basic of such technology has been adopted since 2010 with Namibia and South Africa at the forefront (Iwenwanne, 2017; Sambo & Alexander, 2018).

In Nigeria, electronic voting was first introduced for the 2011 elections since her return to democratic rule that led to the 1999, 2003 and 2007 general elections (Awojobi, Ayakpat & Oladimeji, 2014). The technology was upgraded for the 2015 general elections by introducing biometric PVC[i] and SCR[ii] machines. Although the new technology was still evolving, it was deemed sufficient to redeem Nigeria's election credibility (Sambo & Alexander, 2018). Nevertheless, this was thought to have a bearing on level of people literacy in the new technology.

According to Summers et al. (2014), electronic voting literacy is the technical knowhow and/or knowledge of administering or interfacing with digital systems adopted for election activities. An election is a formal group decision-making process by which a population chooses an individual to hold public office (Webb, Heinz and Gibbins, 2015). In a political sense, it is a sensitive democratic process for which electronic voting technology is sought ensure better election performance. NCSL[iii] (2016) defines electronic voting technology as the use of computerized systems to execute any election activities (Zissis, 2011). There are two forms of electronic voting, namely physically supervised electronic voting (PSEV) and remote electronic voting (REV). In the context of this study, research was about PSEV, which mainly involves location of electronic machines at polling stations (Zissis & Lekkas, 2011). In whatever forms, electronic voting propels election performance when easily used by poll administrators and widely_interfaced by the electorate._Kofi (2016) refers to election performance as the extent to which an election is successfully delivered, and the outcome is recognized as free, transparent and credible.

This kind of electoral credibility was never attained in Nigeria's previous elections of the administered through traditional manual systems (Sambo & Alexander, 2018). The manual technology exacerbated lots of electoral irregularities, the gravest of which was vote-rigging with impunity. Elections were easily manipulated than would be in the new technology dispensation. According to reports on recent elections, the new technology significantly reduced past election irregularities the country grappled with but even the 2015 elections faced challenges (Iwenwanne, 2017; Muluzi, 2015; Osita, 2016). One on the challenges was that even then computer literacy rate was still low among Nigerians yet ICT utilisation need some level of literacy. There was fear that some illiterate potential voters could have stayed back home in 2015

to avoid embarrassment from the computerised voting process (Aderounmu, 2018; Ayeni & Esan, 2018; Osita, 2016). This signaled a possibility of technology literacy constraints, which however warranted this research due to lack of accurate evidence about the level of knowhow and election performance implications of the new technology. Previous related scholarly research was mute about that (Adams, 2016; Aderounmu, 2018; Awojobi et al., 2014; Ayeni&Esan, 2018; Iwenwanne, 2017; Muluzi, 2015; Osita, 2016). It was therefore unknown whether such redemptive electoral technology was easily administrable to poll mangers the electorate.

1.2 **Statement of the Problem.**

Nigeria's 2015 elections were in particular lauded for the use of biometric PVCs and SCR machines as well as a peaceful post-election (Sweeney, 2015), but there were still some technology efficiency and electoral performance gaps owing to technology literacy constraints. In areas like Lagos, Bauchi, Enugu, Edo, Kaduna and Niger states, computer literacy rate was believed to low especially among the potential electorate, yet electronic voting technology requires some measure of ICT literacy. There was also no evidence of poll workers' competence in such technology (Aderounmu, 2018; Ayeni & Esan, 2018; Osita, 2016). All such challenges were however unverified as previous reports were silent about the same and how they wrought the very electronic technology Nigeria adopted to correct past electoral wrongs on electoral manual systems. The related literature was also not clear on the consequent level of election performance (Adams, 2016; Aderounmu, 2018; Ayeni & Esan, 2018; Iwenwanne, 2017; Osita, 2016). This research was therefore timely to bridge the knowledge lacuna especially the content, contextual and approach research gaps.

1.3 General Objective

The general objective of the study was to assess the impact electronic voting literacy on performance of elections in in selected states in Nigeria.

1.4 Specific Objectives

1. To find out the level of administrability of electronic voting technology and its effect on performance of elections in selected states in Nigeria.

2. To examine the level of poll managers' competencies in electronic voting technology and its influence on performance of elections in selected states in Nigeria.

3. To ascertain the level of electorate's knowhow to interface with electronic voting technology and its effect on performance of elections in selected states in Nigeria.

1.5 Research Hypotheses

1. The level of electronic voting administrability does not significantly effect on performance of elections in selected states in Nigeria.

2. Level of poll managers' competencies in electronic voting technology has no significant effect on performance of elections in selected states in Nigeria.

3. The level of electorate knowhow to interface with electronic voting technology has not significant effect performance of elections in selected states in Nigeria.

2. LITERATURE REVIEW

In this section, the review of literature covered the theoretical framework, research model, conceptual framework and previous related literature.

Theoretical Framework

2.1.1 The Technology Enactment Theory

The study was underpinned by the technology enactment theory (TET) although election computerization can be linked to various theories (Schellong, 2007). The theory formed the research framework used to guide the process of research. TET was advanced and has mainly been propagated by Jane, E. Fountain since early 2000s (Founatain, 2001; 2005; 2014). TET presents a framework whose principle aspect is the distinction between objective Information Technology (IT) and Enacted Technology. Objective IT includes Information and Communication Technology (ICT) elements while enacted technology embodies the use of these elements (Founatain, 2001; Schellong, 2007). Specifically, some of the ICT elements include computer related mechanisms, namely computer hardware, software and the Internet in their original state of functionality. In particular, Enacted Technology involves technology integration dynamics (Founatain, 2005). TET therefore suggests that technology innovation cannot be complete unless there is an interaction between adoption and integration. Adoption may be limited to introducing a technolo-

gy by providing ICT elements, which is a significant step but not conclusive. This will therefore require integration or utilisation of the elements which however depends on people literacy in the technology or ICT elements (Founatain, 2001; 2005; 2014; Schellong, 2007). On basis of its postulation, TET was relevant to this study because its perspectives of ICT elements could be perceived as the electronic voting systems adopted by Nigeria, while one of the integration dynamic under study was literacy about the technology. The interaction of these perspectives was basis of the conceiving the independent electronic voting variable perceived to influence election performance, as an outcome (Founatain, 2001), the study set out to explain.

2.1.1 Research Models

There is a range of models related to technology utilisation, but in this study the review centres on the diffusion of innovations model (DOIM) and the motivation model (MM). The MM is very relevant to the concept of study, but the DOIM was the adopted model used to direct research because it offers a comprehensive theoretical scope for exhaustive analysis of the subject of research. According to Taherdoost (2018), DOIM model integrates three major components, namely characteristics of an innovation, adopter characteristics, and innovation decision process. The characteristics of an innovation component involves compatibility and complexity of innovation, while the adopter characteristics cog specifies categories of adopters, namely early adopters, innovators, early majority late majority and laggards. The innovation decision facet features knowledge, and implementation (Sila, 2015). All these conceptual angles the DOIM were very closely useful variable analysis of the current study. innovation characteristics were used to find out electoral implications of technology administrability while the innovation decision and adopter facets was used to examine the implications of technology literacy of poll workers and electorates about Nigeria's electronic voting adopted.

According to the Motivational Model (MM) technology use is determined by intrinsic motivation and extrinsic motivation. Extrinsic motivation involves the extent to which users are inspired to perform an activity perceived instrumental in achieving valued outcomes distinct from the activity itself such electoral credibility. In the case of intrinsic motivation users will want to perform an activity for no apparent reinforcement but the process of performing the activity per-se (Davis, Bagozzi and Warshaw, 1992). Davis et al. (1992) posit that extrinsic motivation can be conceived perceived usefulness of tech-

nology while intrinsic motivation may regarded as perceived ease of use. In this study, the ease of use of the main notion coopted for assessing the administrability of the new technology, people literacy levels of the technology and related implications on its perceived usefulness.

Conceptual Framework

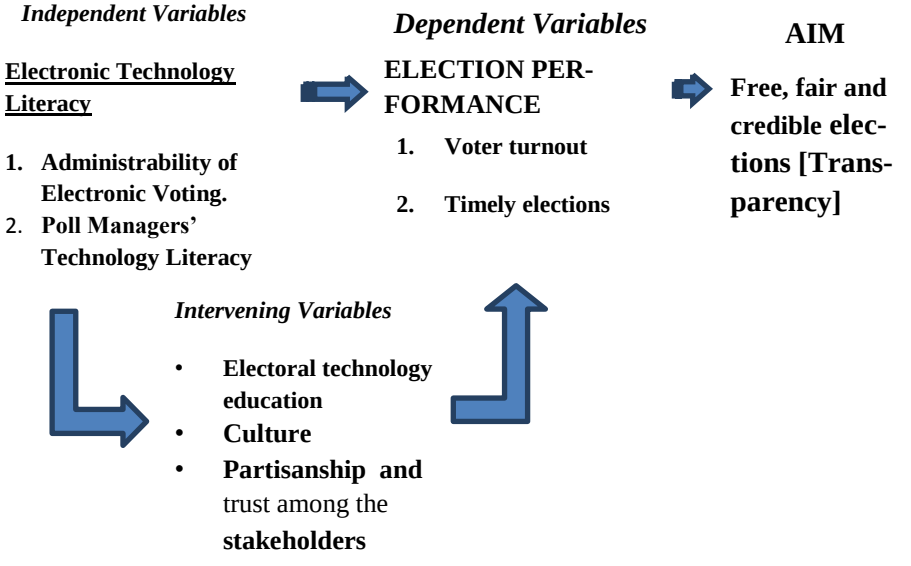


Figure 1. A conceptual framework of the impact of electronic technology literacy on election performance

Source: Adapted from The Technology Enactment Theory (Founatain, 2001; Schellong, 2007) & Diffusion of Innovation Model (Taherdoost, 2018).

2.2 Related Literature Review

In this section, the review of related literature was made along variable associations consistent with specific objectives of the study. The variable relationships included the effects of electronic technology adminstrability, poll workers' technology literacy, electorate's technology literacy and on election performance, respectively. To begin with, a report by Roggemann (2017) on "investments in internet access" specifies that digital literacy programs address the practical skills required to access, navigate, and use the internet and internet-enabled devices such as smartphones. Critical digital literacy, according to

Gianfranco Polizzi from London School of Economics, aims to empower users to consume content critically by identifying issues of bias, prejudice, misrepresentation and, indeed, trustworthiness. Roggemann (2017) gathered that in highly digitalized societies like Western countries, critical digital literacy goes beyond understanding digital media content, to include knowledge of the wider socio-economic structures within which digital technologies are embedded. Like critical digital literacy, electoral related ICT literacy should go beyond computer applications literacy. It was however not clear whether election managers and adhoc staff in the whole of Nigeria were literate enough to effectively run the adopted e-voting system.

In a previous study by Achieng (2014) titled 'adoption and challenges of electronic voting technologies in South African', the findings suggest that e-voting has raised user competency issues due to the technology complexity involved. Achieng (2014) defines complexity in the context of the study as the degree to which electoral technology innovation is perceived by potential adopters as being relatively difficult to use and understand. It was found out among election managers and volunteers in South Africa that the easier technology is perceived, the greater the potential of adoption and vice versa. E-voting in the country, it was found out, is well administered by the sufficiently ICT literate (Achieng, 2014). Further, Achieng (2014) reports that, to the electorate the difficulty of using the technology was a major concern, especially when it comes to electoral involvement of all citizens regardless of their level of literacy. The findings revealed that electronic enabled elections are difficult to effectively manage and participate in by the ICT-illiterate with no prior knowledge of computerised applications to use on manipulate e-voting technologies with ease. The study reports that people in rural South Africa find e-voting technologies difficult to use especially those that have never used computers before. This observation is about South Africa, but it was also highly suspected in Nigeria, which in that respect remained obscure in existing e-voting literature due to the related knowledge gap.

In Amegnran's (2017) research sought to assess electoral process challenges through poll workers' performance in Togo's April 25, 2015 general elections, poor training is identified as of one of the key findings among deficiencies undermining poll workers' performance. Other challenges noticed include ill-conceived legal framework, lack of infrastructure, personal ineptitude, underfunding, partisanship, and tribalism. Findings further indicate that underper-

forming poll workers led to long lines of voters, voter suppression, inaccuracies in vote counts, and delay in results announcement. Accordingly, ICT was an impediment to what e-voting can contribute to election credibility. A similar assessment had to be made in Nigeria to cater for approach, contextual and locational research gaps considering that Amegnran's study was only qualitative and that Togo is a different locality with distinct contextuality.

In his keynote Lecture delivered at the 5th Covenant University Conference on e-Governance in Nigeria, Aderounmu (2018) pointed out that poor education is a challenge stalling the advantage of ICT in our electoral culture. It was further noted that illiteracy is still rampant among Nigerians, yet ICT deployment needs some measure of literacy to be effective in the electoral process. And due illiteracy, some Nigerian voters face the risk of being disenfranchised due to the fear that they may not handle ICT tools deployed for election purposes. In relation to the above, Amuzie's (2015) research on electronic voting system and its role in ensuring credible electoral process in Nigeria had specifically observed the need for technical competency to manage the new electoral technology innovation. This, it was found out, is a key leeway to intensively address the discretionary and obscure fuss that had surrounded Nigeria's elections in decades. These were a leading hint of how ICT literacy could be a serious concern in Nigeria. However, there was need for a micro and quantifiable research to address the scope and approach gaps in Professor Aderounmu and Amuzie's presentation.

2.3 Summary

In the literature review above, the technology enactment theory analyzed and adopted as the underpinning theoretical framework used to guide the study. As such, it was adapted for designing the conceptual framework, which was in turn used to illustrate the study variable relationships. This guided the empirical literature review, made according to the specific research objectives. The empirical review was used to identify research gaps, the main of which included the temporal gap, contextual gap, content research gap, approach gap, specificity gap and locational gap. These gaps were the reason why this study justifiably set out to assess the effects of electronic technology literacy on election performance in selected states in Nigeria.

3. METHODOLOGY

This study adopted three philosophical underpinnings as the research philosophy sought for comprehensive grounded theory used to design a methodology for data collection, analysis and interpretation (Mastin, 2008; Raddon, 2014; Uddin & Hamiduzzaman, 2009). The three philosophical compositions included phenomenological philosophy, positivist philosophy and interpretive philosophy. The study employed an exploratory, descriptive correlational research design based on the quantitative approach (Creswell, 2008; Harwell, 2010; Neuman, 2003; Van der Mescht, 2014). The study population targeted for research consisted of several categories each of which was represented in the study sample of 265 respondents from the six States of study as specified in Table 1. The study sample was determined using the Minimum Sample Procedure (Greene, 2012; Ireda, 2018).

Table 1

Study sample by category

Category	States ($\frac{C \times S}{N}$)						Total
	Bauchi	Edo	Enugu	Kaduna	Lagos	Niger	
INEC***	16	14	15	13	19	17	94
SIEC†††	16	14	15	13	19	17	94
PP‡‡‡ Executives	5	6	6	5	8	5	35
Electoral CS§§§	3	3	3	3	5	4	21
Electorate (Social Groups)	3	3	4	3	4	4	21
Total	43	40	43	37	55	47	265

Source: Researcher (2018)

*** Independent National Electoral Commission

††† State Independent Electoral Commission

‡‡‡ Civil Society

§§§ Political Party

The sample size in Table 1 was selected using purposive sampling, stratified random sampling and convenience sampling techniques. Eighteen (18) INEC staff and 7 political party executives were selected using purposive sampling and asked to fill interview guides. Other 76 INEC staff and 28 Political Party Executives as well as 94 SIEC staff were selected using stratified random sampling and asked to fill the 5-Likert Scale questionnaire. The rest 21 Electoral Civil Society executives and 21 members of the electorate were selected using convenience sampling. The electorate were represented by community development associations earmarked from across the six States.

The collected raw data was presented, analyzed and interpreted using descriptive and inferential statistics based on the Scientific Package for Social Scientists (SPSS), version 20. The descriptive statistical analysis tools used comprised the arithmetic mean ($\bar{x}$), and standard deviation (S). The inferential statistical analysis tools adopted included Pearson's correlation coefficient and multiple linear regression. In order to accurately interpret descriptions of the research variables and their covariance, respective interpretation scales were adopted for each of the analysis tools. The variables included election performance, electronic technology administrability, poll managers' literacy and electorate's literacy in the electoral technology. The arithmetic mean ($\bar{x}$) was interpreted as: 1 = 'Very low', 2 = 'Low', 3 = 'Moderate', 4 = 'High', 5 = 'Very High' (Kostoulas, 2013). The standard deviation scale indicated that $\geq$ 1.5= more spread from the mean and <1.5= closely clustered or less spread around the mean (Bland & Altman, 1996). The Pearson's correlation coefficient scale was that $\leq$ 0.35= weak correlation; 0.36- 0.67= moderate correlation, 0.68- 0.89 = strong correlations and $\geq$ 0.9= very strong correlation (Asuero, Sayago, & Gonz´alez, 2006; Taylor, 1990). Statistical significance scale for Pearson's Correlations was $p \leq 0.01$ while for Multiple linear regression, it was $p \leq 0.05$ (SPSS, 20.0).

4. REASECRH RESULTS

The findings of the study were generated from 251 respondents of the initially planned 265 study sample. This represented a 94.7% response rate which according to Babbie (2007) was far above the recommended minimum rate of 70% at which the sample findings are enough to be generalized for the target population. The main findings in this section, were analysed, interpreted and

discussed in a way corresponding to specific research objectives. In that case, the dependent variable was described, and its covariance with the independent variables was analysed hypothesis by hypothesis respectively drawn from the same research objectives. All this was however, preceded by findings on the background variables respondents.

4.1 Background of Respondents

Respondents' background was ascertained to authenticate their responses (Kaya, 2013). Only questionnaire respondents (n=192) were profiled considering their perceived average status in the study. Regarding gender, 62.2% of the respondents were male and the rest 37.8% were female. About age, almost half (46.9%) of the respondents were middle aged. Stern (2016) specifies that a middle aged person falls between 35 and 58 years. The rest 53.1% of the respondents were youths but all eligible to vote since they were above 18 years old (INEC, 2018). In terms of level of education, 6.3% of the respondents had a certificate of secondary education (CSE), while only 32.3% had college diplomas, 37.5% had a bachelor's degree, and 21.4% were holders a master's degree, while 2.6% were PhD holders. None of the respondents had just primary education graduates. Concerning their period of stay (or work) in the States of research, majority (60.2%) of the respondents had been there for over 10 years. Even respondents with at least half a year's experience were conversant enough a reliable comment. For their electoral participation, almost all of respondents (99.7%) were involved in the 2015 elections. The rest had at least participated in a previous election. The profile characteristics above suggest that all respondents under scrutiny could be relied on for the questionnaire survey.

4.2 Description of the Dependent Variable: Election Performance

Performance of elections in each of the six States of study was investigated based on 3 constructs adopted as key electoral success indicators; vote casting success, collation reliability and election credibility. Both statistical and qualitative data were generated on these electoral performance indicators. The statistical findings were presented in Table 2.

Table 2

Descriptive statistics on election performance in selected States of study

Item	N	Mean	Std. Deviation
1. Vote Casting Success ('vtcsts')	192	3.45	1.09
2. Efficacy of vote collation process ('efvtcolp')	192	3.24	1.12
3. Election credibility	192	3.34	1.12
Grand Average Index ('Lvlelperf')	192	3.34	1.11

Source: Field survey (2018)

According to grand average indices ('Lvlelperf') in Table 2, the 2015 general elections in the States of study were rated as largely well performed ($\overline{x}$= 3.36; S= 1.11). This follows a highly rated vote casting ($\overline{x}$= 3.45; S= 1.09), a relatively rated vote collation process ($\overline{x}$= 3.24; S= 1.12) and a highly rated election credibility ($\overline{x}$= 3.34; S= 1.12). These statistics as well as interview and focus group discussion reports suggest that generally the level of performance of the 2015 general elections was high in much of Nigeria despite some reservations in some parts of the country. This electoral success could be partly attributed to the technology shift from manual to electronic technology which according to Laverty (2011), was for the first time adopted in 2011 following lingering great concern over electoral quality of Nigeria's past general elections.

Basing on statistics in Table 2 and the recommended rule of thumb (Bulmer, 1979), the average skewness of data on election performance was approximately symmetric ($b_{1=}$ -.381). This suggests that the data was normally distributed and could, according to the skewness principle (Sweet & Grace-Martin, 2003), be applicable to the following inferential analysis of Pearson's correlations and multiple linear regression adopted in this study to verify the research hypotheses.

4.3 Verification of Hypothesis One: Electronic Technology Administrability and Level of Election Performance

Findings in this theme are consistent with research objective one and were used verify the related null hypothesis. To clearly verify the hypothesis, the level of electronic technology administrability, as the implicit independent variable, was first described before inferential analysis could be made about its effect on election performance. The statistical descriptions of the variable were presented in Table 3.

Table 3

Descriptive statistics on the level of administrability of the electronic voting technology

Construct	N	Mean	Std. Deviation
1. Electronic voting require no complex computer knowhow	192	3.20	1.12
2. Electronic voting technology adaptable by poll workers	192	3.20	1.19
Average Index ('AdmeVt')	192	3.20	1.16

Source: Field survey (2018)

In Table 3, the average indices ('AdmeVt') suggest that the administrability of Nigeria's electronic voting technology was moderately rated in much of the states of research ($\bar{x}$= 3.20; s= 1.16). This generates from levels of simplicity of the new technology fairly rated at $\bar{x}$= 3.20; S= 1.12, and the adaptability of the technology also moderately rated at $\bar{x}$= 3.20; S= 1.19. That meant that the level of administrability of the new electoral technology was relative in the States of survey. This was supported by qualitative reports from related interviews and focus group discussions.

With knowledge of the level of electronic technology administrability, Pearson's correlation coefficient and multiple linear regression analyses were made to determine its effect on lection performance in the states of study and Nigeria in general as indicated in Table 4.

Table 4

Correlation and Regression (Model Summary) Coefficients

CORRELATIONS

		Level of Election Performance
Electronic technology Administrability	Pearson Correlation	.967**
	Sig. (2-tailed)	.000
	N	192

**. Correlation is significant at the 0.01 level (2-tailed).

MULTIPLE LINEAR REGRESSION

Model	R	R Square	Adjusted R Square
1	.968a	.936	.936

a. Predictors: (Constant), Electoral voting technology requires computer knowledge and skills, 2. The electronic technology not been difficult to administer among poll workers.

Source: Field survey (2018)

According correlation results in Table 4 statistics $r= 0.967^{**}$; $p<0.001$, suggest that there was a linearly significant association (H_A) between levels of electronic technology administrability and 2015 election performance in the States of survey. Regression results in the table show statistic $R^2= 0.936$. This means e-voting administrability predicted 93.6% elections success in such states. The rest 6.4% (0.064) was predicted by other electronic technology characteristics. It was concluded administrability of the new technology significantly affected

election performance not in the States of study but the rest of Nigeria. Null Research Hypothesis One was rejected.

4.4 Verification of Hypothesis Two: Poll managers' Electronic Technology Literacy and Level of Election Performance

In this theme the independent variable about poll workers' technology literacy was also described before its effects on election performance could be determined. The descriptive findings capture the how poll workers were competent in handling the new electoral technology. The statistics registered were summarized in Table 5.

Table 5

Descriptive statistics on the level of Poll managers' technology literacy

Construct	N	Mean	Std. Deviation
1. Poll workers had prior computer application knowledge	192	3.24	1.16
2. e-Election managers well trained about e-voting	192	3.13	1.15
3. Job competency development provided for poll workers vis-à-vis e-Voting	192	3.24	1.12
4. Service delivery of poll workers good enough with the e- voting technology	192	3.14	1.17
Average Index ('Pwkcomp')	192	3.19	1.15

Source: Field survey (2018)

The average indices ('Pwkcomp') in Table 5 suggest that, poll workers' literacy about electronic voting technology was relatively rated at $\bar{x}$= 3.19; s= 1.15. This transforms from individual descriptive statistics about Poll workers prior computer applications knowledge fairly rated at $\bar{x}$= 3.24; s= 1.16); e-voting training of Poll workers moderately rated at $\bar{x}$= 3.13; s= 1.15; Poll workers' technology competency development rated at $\bar{x}$= 3.24; s= 1.12, and Poll workers' e-supported service delivery also moderately rated at $\bar{x}$= 3.14; s= 1.17. This implies, there level of Poll workers' literacy about Nigeria electronic voting was moderate in the States of survey and the rest of the country.

Having described the level of Poll workers' electronic technology literacy, inferential tools were administered to determine the effect of such technology literacy on election performance. Accordingly, Pearson's correlation and Multiple Regression coefficients were computed as summarised in Table 6.

Table 6

Correlation and Regression (Model Summary) Coefficients

CORRELATIONS

		Technology Acceptance
Poll workers' technology literacy	Pearson Correlation	.968**
	Sig. (2-tailed)	.000
	N	192
	**. Correlation is significant at the 0.01 level (2-tailed).	

MULTIPLE LINEAR REGRESSION

Model	R	R Square	Adjusted R Square
1	.971[a]	.943	.942

a. Predictors: (Constant), Poll workers had prior computer application knowledge, e-Election managers well trained about e-voting, Job competency development provided for poll workers vis-à-vis e-Voting, Service delivery of poll workers good enough with the e- voting technology.

Source: Field survey (2018)

According to variable correlations in Table 6, the 2015 election performance in the States studied was linearly significantly associated with Poll workers' electronic technology literacy at r= 0.968**; p<0.001. In particular, regression statistic R2= 0.943 indicates that this kind of e-voting literacy predicted 94.3% success of such elections. The rest 5.7% (0.057) was predicted by other technology adopter characteristics. This deduces that Poll workers' literacy about the new technology significantly affected the 2015 election performance

in the States of study and Nigeria in general. In that case, Null Research Hypothesis Two not accepted.

Verification of Hypothesis Three: Electorate's Electronic Technology Literacy and Level of Election Performance

This section covers findings that describe the level of Electorate's literacy about Nigeria's recent electronic voting and inferential statistics about its effect on performance of elections of study. The descriptive statistical results generated were presented in Table 7.

Table 7
Descriptive statistics on Electorate's literacy about Nigeria's electoral technology

Descriptive Statistics		Indices
Mean		3.21
	Upper	3.38
	Lower	3.05
Std. Deviation		1.15
Skewness		-.239

Source: Field survey (2018)

The statistics in Table show, Electorate's literacy about the electronic voting technology was fairly rated at $\bar{x}$= 3.21; s= 1.15 in the States of research. This suggests, Nigeria's recent electronic voting technology relatively known and interfaced by the electorate in such States and the country as whole.

This understanding was followed by Pearson's correlation and regression tests administered to determine the effect of such technology literacy on performance of the 2015 election as presented in Table 8.

Table 8
Correlation and Regression (Model Summary) Coefficients

CORRELATIONS

		Technology Acceptance
Electorate's electronic technology literacy	Pearson Correlation	.963**
	Sig. (2-tailed)	.000
	N	192
	**. Correlation is significant at the 0.01 level (2-tailed).	

MULTIPLE LINEAR REGRESSION

Model	R	R Square	Adjusted R Square
1	.963[a]	.928	.927

a. Predictors: (Constant), Electorate's Usability of e-Voting Technology.

Source: Field survey (2018)

Correlation in the table above show that at r= 0.963**; p<0.001 2015 election performance in the States of study was at linearly significantly correlated to Electorate's literacy on Nigeria's electronic voting. Partially statistic R2= 0.928 indicates that such literacy predicted 92.8% election success. The rest 7.2% (0.072) was predicted by other technology adopted features. It was thus deduced that the knowhow of the Electorate about the new electoral technology significantly affected performance of such elections in the States of research and the rest of Nigeria. As result Null Research Hypothesis Three was rejected.

4.5 Grand Multivariate regression analysis of technology acceptance and election performance

This section covers overall results on how the literacy about the electronic voting technology generally predicted the 2015 election performance in the states of study in Nigeria. The results were generated using a grand multiple linear regression analysis as presented in Table 9.

Table 9

Model Summary

Model	R	R Square	Adjusted R Squ	Std. Error of the Estimate
1	.969a	.938	.938	.25198

a. Predictors: (Constant), Administrability of e-Voting Technology, Poll workers' competency in the Technology, Electorate's Interface with the Technology

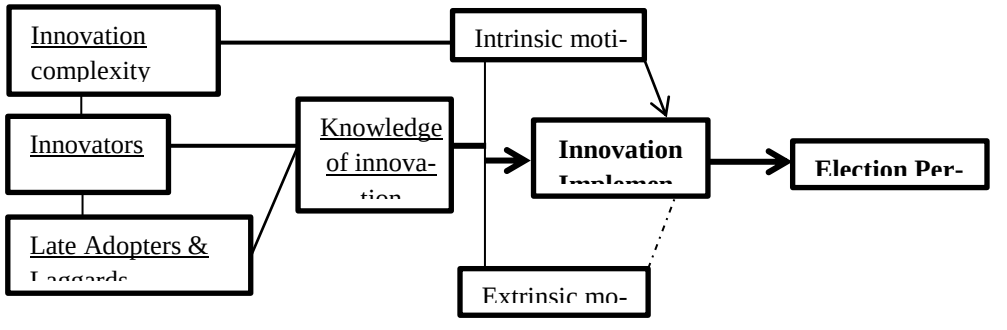
Source: Field survey (2018)

According to statistics in Table 9 at R^2= 0.938, level of literacy about Nigeria's e-voting predicted 93.8% success of elections in such states of research. The rest 6.2% (0.062) could be predicted by other technology dynamics of the country's electronic voting. This infers that increase in poll workers' and electorate's literacy about the new technology propelled election performance, and vice versa, in the States of research and Nigeria at large. Therefore Null Research Hypothesis Three was disapproved.

4.6 The Proposed Model: Jibia's Technology Literacy Model

A results of the research findings above study proposes a new model dubbed, "Jubia's (2019) Technology Literacy Model. The model was designed as presented in Figure 2.

Figure 2. Jibia's Technology Literacy Model



Source: Researcher (2019)

Jubia's model builds on and forms an interplay of the diffusion of innovation (DOIM) model and motivation model (MM) (Davis et al., 1992; Taherdoost, 2018). The new model is specific about the postulations of the DOIM and offers more factors and the process that operationalize motivation of technology utilization especially intrinsically. The factors include the three independent variables of technology administrability, Poll workers' and Electorate's literacy while the process is implementation of the electoral technology.

1.1 Summary of Findings

The findings of the study were summarized hypothesis by hypothesis. Regarding null hypothesis one, the study describes the administrability of Nigeria's electronic voting technology as being moderate in much of the country. In particular, it infers that this level of technology administrability significantly affected the 2015 election performance in the country as opposed to the related null hypothesis. In the case of null hypothesis two, the study shows that the level of Poll workers' literacy about the new technology was widely relative in the country and that this also significantly affected performance of the elections of study. This invalidated the related null hypothesis. About null hypothesis three, the study specifies that Electorate's ability to interface with such electoral technology was also fairly rated. It however significantly affected the election result. According to the study, the 2015 election result was credible owing to the levels and forms of technology literacy above.

1.2 Conclusions

It was concluded that each of the factors of technology literacy of study has a significant impact on the performance of an election. Increase in technology administratbility, Poll workers' electronic voting literacy, and Electorate's proficiency to interface with the technology can positively propel election performance in the six States of study, the rest of Nigeria and world.

1.3 Recommendations

In view of the study findings, this study recommended that there was need to simplify further electronic voting and build or maintain competencies of all stakeholders including Poll managers and the electorate so as to boost implementation and electoral success of the technology inn Nigeria. Electoral technology competences should be well sustained or improved through continuous

electoral technology education by electoral management institutions like INEC and SIEC and as well as other none state partners such as Electoral Civil Society.

The study also recommended that further research could be done on the following aspects to address perceived knowledge gaps: q) other technology factors affecting election performance; b) performance of elections in other institutional contexts, c) other States of Nigeria or elsewhere in the world and d) the same technology subject after a longer period.

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RELATIONSHIP BETWEEN METEOROLOGICAL VARIABLES AND EFFECTIVE EARTH RADIUS FACTOR OVER AUCHI AREA OF EDO STATE, SOUTH-SOUTH, NIGERIA

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Abstract

The effective earth radius factor; k-factor is a major parameter in the prediction of the local radio wave propagation conditions of the lower atmosphere from meteorological variables. In this study the k-factor values were calculated and analyzed from the measurements of air temperature, relative humidity and atmospheric pressure in Auchi area of Edo State, South-South, Nigeria using a self implemented cost effective portable weather monitoring device for a period of one year; 2017, so as to determine the relationship between these meteorological variables and the k-factor values. The fixed measuring method by placing the weather monitoring device on 50 m height above sea level was employed for the measurements of the various meteorological variables at the administrative block of Edo University Iyamho. The results show that the calculated k-factor values range from 1.06 to 1.94 with an average value of 1.47 and were generally higher during the months with much rainfall compared to that of the months with lesser rainfall. The measured meteorological variables were having significant influences on the calculated k-factor values during all the months, and these influences were more pronounced during the months with much rainfall compared with the months with lesser rainfall. The influence of the air temperature was higher compared to the other meteorological variables. The results that are obtained from this study should be taken into account for enhancement and improvement purposes in radio communication systems.

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KEYWORDS: Lower Atmosphere; Air Temperature; Atmospheric Pressure; Relative Humidity; Radio Wave

1.0 Introduction

In the prediction of the local radio wave propagation conditions of the lower atmosphere, meteorological variables are very useful because of their influence on radio wave communication links in the atmosphere (Agbo et al., 2013; Ukhurebor and Azi, 2018; Ukhurebor et al., 2018).

The electromagnetic waves that are propagated in the lower atmosphere are mainly affected by the different components that made up the atmosphere, this is as a consequence of the variations of some meteorological variables such as air temperature, atmospheric pressure and relative humidity and these variations made the refractive index of the air in the lower atmosphere to vary from place to place (Korak-Shaha, 2003; Agbo et al., 2013; Ukhurebor and Azi, 2018; Ukhurebor et al., 2018; Ukhurebor and Umukoro, 2018). The path bending of the electromagnetic waves as a result of the non-homogeneous spatial distribution of the refractive index of air causes harsh effects such as multipath fading and interference, attenuation due to diffraction on the terrain obstacles which is also known as the radio holes (Martin and Vaclav, 2011; Ukhurebor et al., 2018; Ukhurebor and Umukoro, 2018). The variation in refractivity in the lower atmosphere is a function of meteorological variables (Agbo et al., 2013; Ayantunji et al., 2011; Okoro et al., 2012; Ukhurebor and Azi, 2018; Ukhurebor et al., 2018).

In order to have a good communication link for radio wave, the transmission medium need to be considered in order to have a better signal from the radio communication network, since the radio wave communication links are influenced by meteorological variables (Adediji et al., 2011; Ukhurebor and Azi, 2018; Ukhurebor and Umukoro, 2018). The attitude and phase scintillations, absorption, scattering of radio wave network signals and other numerous complex mechanisms that occur in the lower atmosphere are caused by the random changes in the surface and vertical refractivity which can cause transmission signals lost and co channel interference. The effect of interference as a result of refractivity difference in the lower atmosphere is much in the humid climate than in the temperate climate regions due to the occurrence

of high intensity humid rainfall (Adediji et al., 2011; Ukhurebor et al., 2018; Ukhurebor and Umukoro, 2018).

Some commonly used format of referring the International Telecommunications Union recommendation, (ITU-R) is presently being used in planning of broadcasting services for frequencies greater than 30 MHz, the mostly used radio propagation wave formulae from this recommendation are obtained from measurements carried out in most temperate climate regions of the world like Europe, Asia and North America. Although, the sub-Sahara African climate is different from these temperate climate regions own, these formulae can still be used for the planning of radio wave propagation services in the sub-continent due to the scarcity of accurate data from these regions, (ITU-R, 2015; Adediji et al., 2011; Martin and Vaclav, 2011; Ukhurebor and Azi, 2018). The radio refractive index is an important parameter in determining the quality of radio signals (Ukhurebor et al., 2018). To determine the characteristics of a radio channel, surface and elevated refractivity data are mostly needed. The surface refractivity is more important for the prediction of some propagation effects than the elevated refractivity. Local coverage, refractivity gradient and other statistics of refractivity provide the most crucial explanation of the likely occurrence of refractivity related influence needed for local radio wave prediction methods (Bean and Dutton, 1968; Adediji et al., 2011; Alam et al., 2016; Martin and Vaclav, 2011; Ukhurebor and Azi, 2018). The assessment of these meteorological variables will definitely enhance a better local radio propagation conditions that will assist radio network service providers in enhancing their quality of services (Ukhurebor et al., 2018).

In this study the measurement results of air temperature, relative humidity and atmospheric pressure were made at 50 m height above sea level at the Administrative block of Edo University Iyamho, Auchi area of Edo State, South-South, Nigeria using a self designed cost effective portable weather monitoring device. The measured meteorological were used to derive and analyze the k-factor. To the best of our knowledge from existing literatures this study is unique not only for the fact that we are using a self implemented inexpensive portable weather monitoring device for the measurements of the meteorological variables but also it is one of the most recent studies on the relationship between meteorological variables and k-factor specifically in Auchi area of Edo State, South-South, Nigeria.

2.0 Materials and Methods

2.1 The Weather Monitoring Device

The weather monitoring device was implemented in such a way that it can be used remotely and the readings are displayed on the user friendly LCD display in numerical digital values for atmospheric temperature (^{o}C), atmospheric pressure (mbar), relative humidity (%) and light intensity (lux) which can also be sent to computer via the programmed micro SD card or/and through the serial port; the Arduino SD card module. The user has the option of choosing how often the meteorological variables will be logged, measured, recorded, stored and displayed. The acquired meteorological variables are analyzed and the LCD displays the values respectively. In addition, the meteorological variables for each day are saved on the micro SD card in Excel format on a separate file with each file created with a file name that corresponds to the date and time when the meteorological variables were acquired. The users also have the option to stop the meteorological variables acquisition process at anytime by interrupting the routine. Details of the construction and implementation of the weather monitoring device including its validity is contained in Ukhurebor et al., (2017a).

2.2 Area and Method of Measurements

The measurements were done at the administrative block of Edo University Iyamho, Auchi area of Edo State, South-South, Nigeria which is located within Latitude 7.07°N and Longitude 6.27°E of the Greenwich Meridian at 50 m height above sea level. The area experiences the humid tropical climate, which is characterized by wet and dry seasons; the vegetation is that of the Savannah, with mostly open grassland and few scattered fire resistant trees. The topography is relatively undulating and it slopes from the north of the area to the south (Ukhurebor and Azi, 2018; Ojeifo and Akhimien, 2013).

The fixed measuring method by placing the weather monitoring device on 50 m height above sea level was employed for the measurements of the various meteorological variables at the administrative block of Edo University Iyamho, Auchi area of Edo State, Nigeria for continuous measurements. Although, the weather monitoring device measures four meteorological variables as stated earlier, only the daily records of air temperature (^{o}C), atmospheric

pressure (mbars) and relative humidity (%) were used for this particular study. The records cover twenty four hours each day from 00 hour to 2300 hours local time at intervals of one hour of which the average values from each day are then copied from the micro SD card to the computer from the weather monitoring device. The measurements of the meteorological variables were made for a period of one year; January to December, 2017.

2.3 Theoretical Background

It has been shown that the electromagnetic waves that are passing through the atmosphere bends, due to the various layers of the atmosphere and its permittivity, but it would have otherwise travel in a straight path if it was homogeneous; as a result of this spatial distribution of the refractive index of the air which causes hostile effects (Martin and Vaclav, 2011; Ukhurebor and Azi, 2018). The atmosphere's refractive index, n and the relative permittivity, ε_r can be connected with (Adediji et al., 2011; Alam et al., 2016; Ukhurebor and Azi, 2018);

$$n^2 = \varepsilon_r \tag{1}$$

Since the value of the atmospheric refractive index is ≈1 and the variation is infinitesimal. A suitable parameter that can be used when modeling the variation of the atmospheric refractive index is the refractivity, N which is defined as;

$$N = (n-1)\times 10^6 \tag{2}$$

N and meteorological variables such as the air temperature, atmospheric pressure, vapour pressured is connected by;

$$N = \frac{77.60}{T}\left(P + 4810\frac{E}{T}\right) \tag{3}$$

N can thus, be expressed as (ITU-R, 2015);

$$N = 77.60\frac{P}{T} + \left(3.73\times10^{5}\frac{E}{T^{2}}\right)$$

(4)

The troposphere refractivity can be divided into two proportions, namely; the dry proportion and the wet proportion. The dry proportion contributes about 70% of the total refractivity in the troposphere. This dry proportion increases with increasing density of the gas molecules and changes with their distribution. It is normally stable and can be calculated from the measured air temperature and atmospheric pressure with an accuracy of about 20% (Agbo et al., 2013; Ukhurebor et al., 2018) using;

$$N_{d} = 77.60\frac{P}{T}$$

(5)

Where P is barometric pressure (millibars) and T is absolute temperature in Kelvin.

On the other hand, the wet proportion which is as a result of the polar nature of water molecules, contributes the main variation of refractivity in the atmosphere and can be calculated (Agbo et al., 2013; Ukhurebor et al., 2018) using;

$$N_{w} = 3.73\times10^{5}\frac{E}{T^{2}}$$

(6)

Where E is partial pressure of water vapor (millibars) and can be calculated from;

$$E = \frac{RH}{100}\times E_{s}$$

(7)

where RH is the relative humidity (%) and E_s which is the saturated vapour pressure (millibars) by;

$$E_s = 6.11 \times 10^{\frac{17.27(T-273.15)}{T-35.85}}$$

(8)

If the height; h of a ray above the earth's surface, the radius; r of the ray curvature and the vertical gradient of refractive index; $\frac{\partial N}{\partial h}$ the horizontal angle of the path; θ to a given point can be written as;

$$\frac{1}{r} = \frac{1}{N}\left(\frac{\partial N}{\partial h}\right)\cos\theta$$

(9)

According to Brussaard and Watson, (1995), r may be connected to the relative earth radius; R in terms of the refractive index gradient;

$$\frac{r}{R} = k$$

(10)

where k is the effective earth radius factor which can now be expressed as;

$$k = \frac{1}{1 + R\left(\frac{\partial N}{\partial h}\right)}$$

(11)

Afullo et al., (1999) in their work show that the k-factor can be used for categorizing the refractive conditions as normal refraction or standard atmosphere, sub-refraction, super-refraction and ducting as the case may be.

Recall that R ≈ 6370 km. Thus, Eqn. (11) may now be expressed in terms of N as;

$$k \approx \frac{1 \Big/ 1 + \left(\frac{\partial N}{\partial h}\right)}{157}$$

(12)

Within the earth's surface, $\frac{\partial N}{\partial h} \approx$-39 N-units/km and this will give a k-factor value of 1.33; with such value we will have what is known as normal refraction or standard atmosphere. Here, radio signals are transmitted along a straight line path on the earth's surface and go into space unimpeded. If $1.33 \succ k \succ 0$, we will have sub-refraction; which implies that the radio waves propagate abnormally away from the earth's surface. But when $\infty \succ k \succ 1.33$ we will have super-refraction and this signifies that the radio wave signals spread irregularly towards the earth's surface; thus, extending the radio horizon and increasing path clearance thereby giving irregularly huge ranges above the line of view as a result of multiple reflections. But, if $-\infty \prec k \prec 0$ there will be ducting and this will make the radio waves to bend downwards with a curvature greater than the earth's own. The radio signals can become trapped between a layer in the lower atmosphere and the surface duct which is the earth's or sea's surface or between two layers in the lower atmosphere which is the elevated duct. In this wave guide-like propagation, very high radio signal strengths can be obtained at a very long range which is far above the line of view (Adediji et al., 2011; Ukhurebor and Azi, 2018).

3.0 Discussion of Results

The analysis for this study was done procedurally via calculation of k-factor from the measured meteorological variables; air temperature, relative humidity and atmospheric pressure using Eqn. 1 to Eqn. 12 accordingly. The monthly calculated k-factor values for the period under consideration range from 1.06 to 1.94 with an average value of 1.47. Some statistical analysis was also done so as to determine their variability. Comparisons of the various measured meteorological variables and the calculated and the k-factor values were also respectively done graphically. The average monthly measured meteorological variables of each of the measured meteorological variables and the calculated k-factor are contained in Table I. The mean values for air temperature, relative humidity and atmospheric pressure were 25.46 ^{o}C, 73.08 % and 1004.56 mbar respectively for the period of the measurements; January to December, 2017.

Table I: Average Measured Meteorological Variables and Calculated k-factor for 2017

Month	Average Air Temperature (^{o}C)	Average Relative Humidity (%)	Average Atmospheric Pressure (mbars)	Calculated k-factor
Jan	28.20	42.70	1001.70	1.16
Feb	31.80	48.20	1002.50	1.30
Mar	30.10	68.70	1004.60	1.50
Apr	29.30	85.20	1007.10	1.40
May	28.40	92.10	1005.70	1.30
June	26.30	92.40	1005.90	1.58
July	25.00	95.30	1004.70	1.72
Aug	26.60	78.60	1003.90	1.88
Sept	25.50	78.40	1005.40	1.40
Oct	25.70	68.90	1005.60	1.44
Nov	27.80	68.20	1004.70	1.40
Dec	26.50	58.30	1002.90	1.52
Mean	**25.46**	**73.08**	**1004.56**	**1.47**

Since the average value of the calculated k-factor is 1.47 and $\infty > \mathbf{k} >$ 1.33, we can inferentially say that the local radio wave propagation condition for Auchi, area of Edo State, South-South, Nigeria is predominantly super-refractive. This signifies that the radio wave signals spread irregularly towards the earth's surface, hence extending the radio horizon and increasing path clearance, thereby giving irregularly huge ranges above the line of view as a result of several reflections.

In Fig. 1 the k-factor values for the period under consideration; 2017 on monthly basis which were obtained from the monthly records is shown. A critical look at this Figure revealed that the months with much rainfall; April,

May, June, July, August, September and October have greater values compared to the ones with lesser rainfall; November, December, January, February and March, the values range from 1.20 to 1.94 during the months with much rainfall; while, the values for the months with lesser rainfall range from 1.06 to 1.62 for the period under consideration. This result again agrees very well with the results of Adediji et al., (2011) and Kolawole (1981).

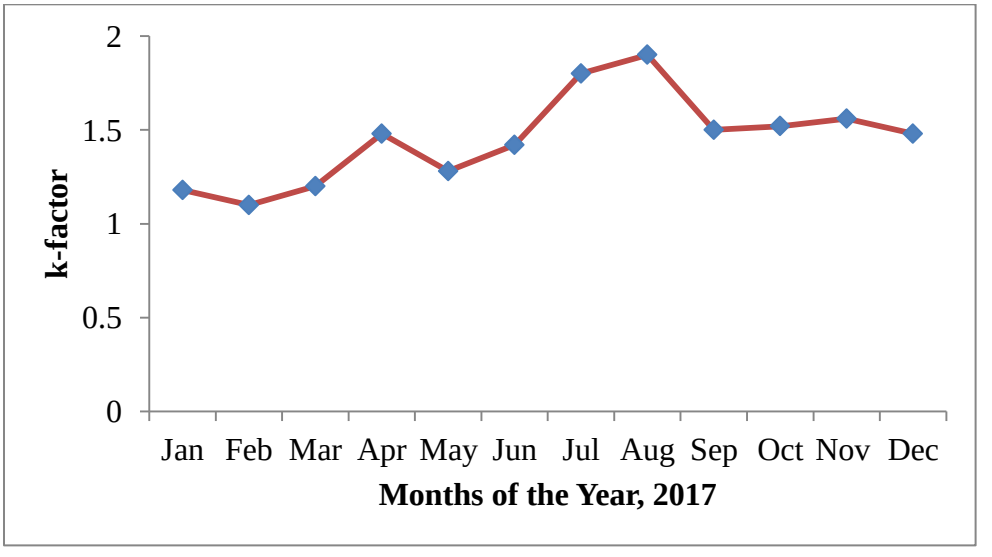

Fig. 1: Monthly Variations of k-factor

Fig. 2 shows the plot of the measured air temperature against the calculated k-factor values during the various months; January to December, 2017, Fig. 3 shows the plot of the measured relative humidity against the calculated k-factor values during the various months; January to December, 2017, while Fig. 4 shows the plot of the measured atmospheric pressure against the calculated k-factor values during the various months; January to December, 2017. It was observed that these measured meteorological variables were having significant influences on the calculated k-factor values during all the months in 2017, and these influences were more pronounced during the months with much rainfall that is; March, April, May, June, July, August, September and October; rainy season, compared with the months with lesser rainfall that is; November, December, January and February; dry season.

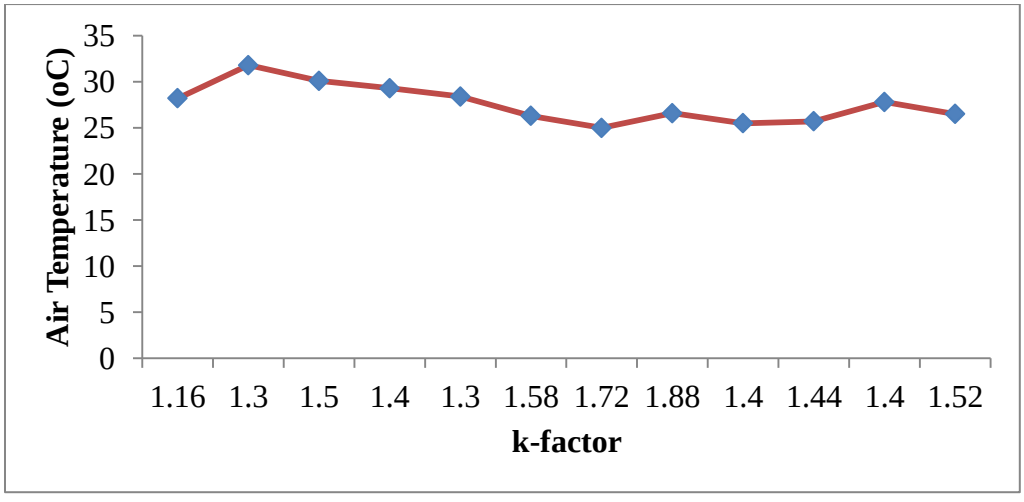

Fig. 2: Air Temperature with the k-factor

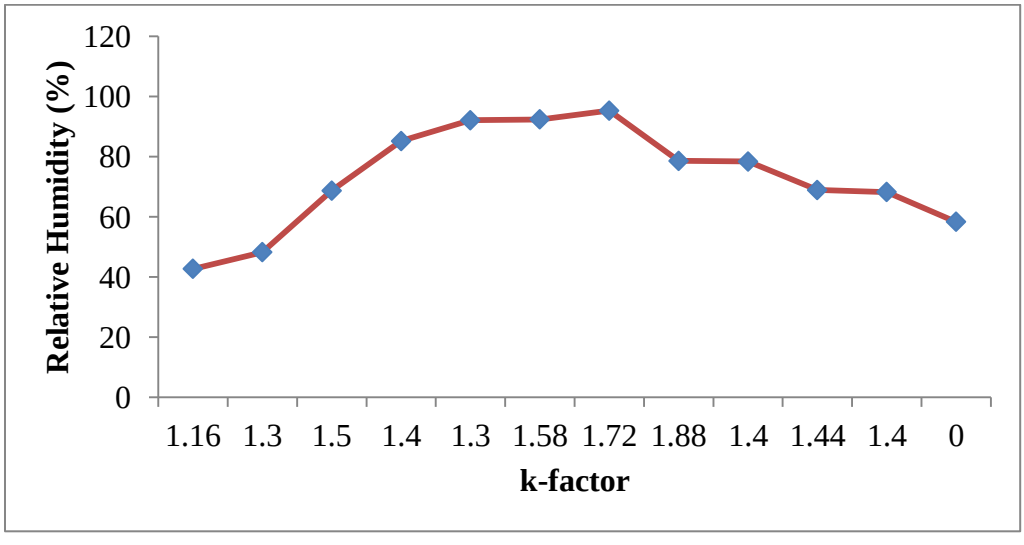

Fig. 3: Relative Humidity with the k-factor

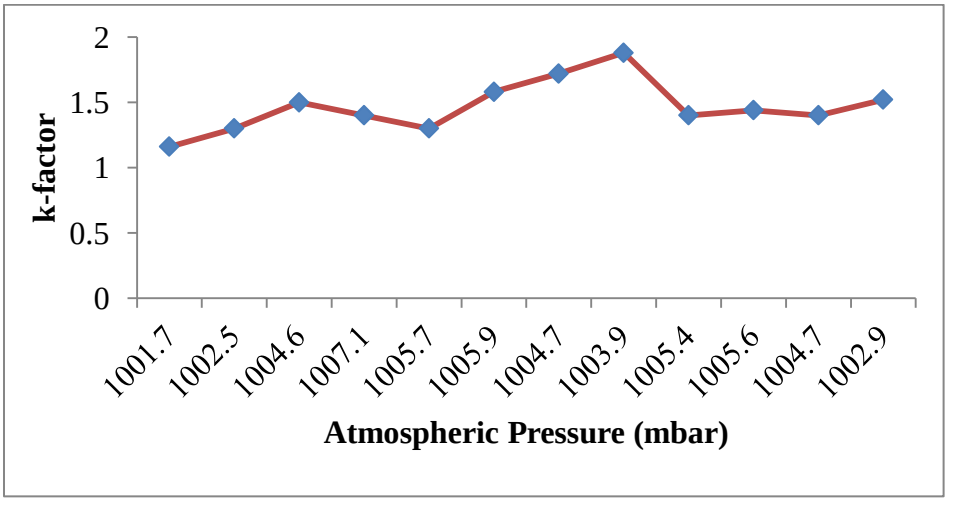

Fig. 4: Atmospheric Pressure with the k-factor

The measured air temperature was observed to have much influence on the calculated k-factor values all through the months in 2017 compared to the other meteorological variables, this again affirm that fact that air temperature has significant influence on other meteorological variables (Ukhurebor et al., 2017b; Ukhurebor et al., 2017c; Ukhurebor et al., 2018).

4.0 Conclusion

The measurements of air temperature, atmospheric pressure and relative humidity were made at 50 m height above sea level in the administrative block of Edo University Iyamho, Auchi area of Edo State, South-South, Nigeria for a period of one years; 2017 using a self implemented inexpensive portable weather monitoring device so as to analyze the relationship between these meteorological variables and k-factor values. The results that were obtained from this study would assist in the enhancement and improvement of radio communication systems**.**

Deductively, the summarized results obtained from this study are:

- The local radio wave propagation condition for Auchi area of Edo State, South-South, Nigeria is predominantly super-refractive.

- The measured air temperature, relative humidity and atmospheric pressure were having significant influence on the calculated atmospheric refractivity during all the months in 2017 and these influences were much during the months with higher rainfall; wet season. The measured air temperature was having much influence on calculated k-factor all through the months in 2017.

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IMPACT OF SERVICE QUALITY ON ELECTRONIC TECHNOLOGY: A PERFORMANCE OF ELECTIONS IN NIGERIA

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Abstract

This study examined the effects of service quality on electronic technology performance in 2015 general elections of the six states in Nigeria such as Bauchi, Edo, Enugu, Kaduna, Lagos, and Niger. These efforts were studied to provide a more credible electoral process, leading to increased citizen participation in future voting exercises and the adoption of several blueprint on electronic voters' registration (EVR). The data collection was conducted based on descriptive correlational research design using quantitative and qualitative approach. The results showed that the level of performance in 2015 general election was high despite the little challenges found in some parts of the country. This trend is attributed to high service quality of automated electoral technology, relative level of acceptance and moderate literacy rate. The result suggested that the electronic voting technology adopted in Nigeria significantly influenced the performance of elections in the six states. It is recommended that the Independent National Electoral Commission (INEC) and other electoral stakeholders should adopt different strategies to improve on the service quality of electronic voting technology for better consistency of election performance.

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Keywords: Service quality, electronic technology, EVR, INEC, electoral stakeholders.

Introduction

The Federal Republic of Nigeria has embarked on a mission to computerize all ministries by increasing the level of adoption and use of information and communications technology (ICT) in the country. The plan involves the initiation of a diversified scope of information systems within governmental organization. For instance, the INEC is one of several organizations targeted by the electronic innovations as a means to advance the policies and agendas (McGrath and Maiye, 2010). The application of electronic innovation was to deployed digital technologies by replacing it with EVR, voter verification, and results transmission. Electronic voting (e-voting) is one of the innovations in which governments try to engage citizens in a development initiative with strategic importance for upholding democracy in a society. E-voting is seen as having the potential to bring transparency to governments' activities and decisions, combat the manipulation that often affects electoral activities (Avgerou et al., 2007).

Indeed, there are many research studies on the effect of e-voting system and adoption of the technology in Africa, but less research work has been conducted on technology performance and service quality of elections, and potential challenges of transition. (Mensah, 2017) studied the factors affecting adoption and use of an e-voting system in Ghana using technology acceptance model. The results showed that over 71.1% of the respondents recommended Ghana's Electoral Commission (GEC) to adopt an e-voting system, and other 28.9% felt the contrary. This was attributed to individual differences with regard to perceived ease of use, system integrity, and perceived credible elections (PCE). (Achieng and Ruhode, 2013) investigated the adoption and chal-

lenges of e-voting technologies in South Africa. It was found that e-voting has raised user competency issues due to the technology complexity involved. In addition, the people in rural experience e-voting technologies difficulties to use especially those that have never used computers before. Another similar study conducted in Togo by (Amegnran, 2017), reported that poor training is one of the key findings among deficiencies undermining poll workers' performance. According to the literature reported by (Bowman and Githaiga, 2015), 2013 Kenya elections encountered several technological problems; laptop batteries were running dead at some polling stations, biometric kits were crashing, and electronic results transmission failure. This trend may be attributed to the lack of technological performance testing and service quality before election.

In Nigeria, (IshaqSalimonu et al., 2013) studied the determinants of e-voting adoption by INEC. A questionnaire survey and 500 managerial staff of the electoral commission as the units of observation was adopted for data collection. An analysis of the data reveals that significant captivated of e-voting in Nigeria were political goodwill, electoral technology progress on the African continent, people confidence in the technology reform and capacity to invest in new technology. It was suggested that there was need for a micro and quantifiable research to address the scope and gaps hinted early on service quality consideration and technology performance in Nigeria. Most of African countries, especially in Nigeria, it is difficult to register voters close to their homes. This trend is due to the insufficient number of voters that biometric smart card readers (SCRs) are programmed to accept in a given polling station. Many voters are therefore registered very far away from their place of residence, and this creates confusion among them when it comes to locating their proper polling station on election day (Iwuoha, 2018).

This research paper aims to study the impact of service quality on electronic technology and performance of elections in Nigeria. In addition, the population target by the study include the entire grownup population (18 years plus) of the six states in Nigeria such as Bauchi, Edo, Enugu, Kaduna, Lagos, and Niger. The purpose of selecting the entire grownup and adult population is to target the population involve in a set of units with quantifiable potentials for which the data are used to make inferences.

1. Research Approach

This study is based on research data collected during post-election, long field trips visits across six geopolitical zones in Nigeria, namely, Niger in North Central (NC); Bauchi in North East (NE); Kaduna in North West (NW); Enugu in South East (SE); Edo in South-South (SS); and Lagos in South West (SW). The federal states engaged in this study are as follows: Bauchi, Edo, Enugu, Kaduna, Lagos, and Niger. The population size of these states, from largest to smallest is as follows: 9,113,605 in Lagos; 6,113,503 in Kaduna; 4,656,066 in Bauchi; 3,954,772 in Niger; 3,267,837 in Enugu; 3,233,366 in Edo (Wikipedia, 2018). The recent statistics in 2018 indicate that there were 2,462,843 registered voters in Bauchi; 2,210,534 in Edo; 1,944,016 in Enugu; 3,932,492 in Kaduna; 6,570,291 in Lagos, and 2,390,035 in Niger (INEC, 2018).

The interviewees mostly belonged to the uneducated, educated and semi-educated middle class, with only shallow knowledge about the government and its activities. The population target by the study include the entire grownup population (18 years old and over) within the six states, and who understand how its affairs are managed. However, the recorded interviews, informal conversations and discussions took place throughout the fieldwork with a diverse group of informants such as websites of the government, INEC,

state independent electoral commission (SIEC) officials, local electoral civil Society (CS), political parties (PP) executives, and external agencies; this fundamentally enlightened and influenced the research.

The number of respondents in the sample strategies through the interview, questionnaire, and focus groups discussion (FGDs) were presented in Table 1. For purposely selection, 27 respondents were asked to fill the interview guides as key informants. As the results selected from stratified random sampling, 198 respondents were asked to fill the questionnaire. In addition, 40 respondents were conveniently selected to participate in the FGDs as summarized in Table 1. The data collected was analyzed and presented using descriptive statistics; arithmetic mean and standard.

Table 1. Summary of the sampling procedure

Sampling strategy	Category	Sampling frame	Sample	Method
Purposive sampling	INEC	521	18	Interview
	PP Executives	205	09	
	Sub total		27	
Stratified random sampling	INEC	503	76	Questionnaire
	SIEC	521	94	
	PP Executives	196	28	
	Sub total		198	
Convenient	Electoral CS	113	20	FGDs
	Electorate	109	20	
	Subtotal		40	

Sampling strategy	Category	Sampling frame	Sample	Method
Grand Total			265	

Source: Field survey (2018)

2. Results and Discussion

2.1. Response rate

The rate of response from the designated sample was computed. The original sample size was 265 respondents intended for the questionnaire survey, interviews and FGDs. The purpose of minimizing the response gap is to dispensed 200 questionnaires instead of 198 as planned, 29 interview guides instead of 27, and invited 44 FGD participants instead of 40 as reported in section 2. The response rate of the intended field survey informants is shown in Table 2.

Table 2. Field research response rate

Instrument	Category	Sample	Returns	Unreturned	*RR (%)	**ARR (%)
Questionnaire	INEC	76	72	04	97.3	98.4
	SIEC	94	92	02	97.9	
	PP Executives	28	28	00	100.0	
	Subtotal	198	192	06		
Focus Group Discussion (FGD)	Electoral CS	20	18	02	90.0	92.5
	Electorate	20	19	01	95.0	
	Subtotal	40	37	03		
Interview Guide	INEC	18	15	3	83.3	91.7
	PP Executives	9	9	0	100.0	
	Subtotal	27	24	3		

Instrument	Category	Sample	Returns	Unreturned	*RR (%)	**ARR (%)
	Grand total	265	253	12		
Grand Average Response Rate (%)						94.2

Source: Field survey (2018) Note: * Rate of Return; ** Average Rate of Return

The results were sufficient to be address as research objectives, because it is recommended that a response rate < 70 % is adequate in social science research (Fincham, 2008).

2.2. **Quality of e-voting technology**

The sample distribution (n=192) on item A and B in Table 3 shows that 17.2% and 14.1% of the respondents strongly agreed and 35.4% and 33.3% others agreed that the electronic voter registration technology was good. Also, 28.1% and 24.5% of the respondents were neutral, while 15.1% and 20.3% disagreed and the rest of 4.2% and 7.8% strongly disagreed in A and B respectively. The results indicate that the electronic technology used for voter registration was good in areas by 52.6% and 47.4% of the respondents, fairly good in parts overseen by 28.1% and 24.5%, and poor in localities of 19.3% and 28.1% of the respondents, respectively.

Table 3. Description of electronic e-voter direct data capture technology

Descriptive tool	Response scale	(A) e-voter registration technology good	(B) e-voter verification technology efficient
Distribution (n=192)	SD	8 (4.2%)	15 (7.8%)
	D	29 15.1%)	39 (20.3%)
	N	54 (28.1%)	47 (24.5%)

	A	68 (35.4%)	64 (33.3%)
	SA	33 (17.2%)	27 (14.1%)
Mean		3.46	3.26
Std. Deviation		1.073	1.163

Source: Field survey (2018)

The statistical result shows that at ($\bar{x}$=3.46) and ($\bar{x}$=3.26) for both A and B respectively, the arithmetic mean is high and the standard deviation generated was very spread at 1.07. This connotes that the quality of electronic direct data capture of voters was highly rated by respondents in most of the states of research despite some reservations from a few respondents.

2.3. **Quality of e-voting technology vs. level of election performance**

The multiple linear regression used in this study was to determine the exact service quality of electronic technology and predicted election performance in the states of study. The results presented in Table 4, shows the specific regression statistics of electoral predictions and quality of electronic technology applications for individual and main activities of the election process. Table (4) and (5) shows the analysis of variance for P-values, where a P-value of less than 0.0500 indicates that the model terms are significant. In this case, electronic voter data capture, vote cast assistive technology, vote collating, vote safety and dissemination are quite significant influences on election. Values greater than 0.1000 indicate the model terms are not significant (Yusuf and Inambao, 2019). The predicted coefficient of determination (R^2) was found to be 0.952 which is in reasonable agreement with the adjusted coefficient of determination (R_a^2) of 0.964; the difference is less than 0.2. This shows that the

(R_a^2) was found to be very high, which implies that the model accounted for 96.4% of the variability in the data.

Table 4. Predictive statistical regression co-efficient of electronic technology adopted for individual electoral activities of the general elections

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	0.141	0.046	-	3.040	0.003	0.050	0.233
1. Electronic direct voter data capture	0.287	0.089	0.314	3.227	0.001	0.112	0.463
2. Electronic voter identification (for vote casting)	0.305	0.147	0.343	2.072	0.040	0.015	0.595
3. Electronic vote collating	0.235	0.117	0.258	2.013	0.046	0.005	0.466
4. Electronic vote safety & dissemination	0.064	0.116	0.071	0.550	0.583	-0.165	0.292

Source: Field survey (2018) Dependent variable: Level of election performance

In the regression statistics, all the electronic poll technologies were important but the most required for improved election performance was electronic voter identification for vote casting, electronic voter data capture, electronic vote collating, electronic vote safety and dissemination in that direction.

Table 5. Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.982[a]	0.952	0.964	0.19243

Note: [a] Predictors: (Constant), e-direct data capture, e-vote collating, e-vote cast assist, e-vote safety and dissemination.

According to Table 5, R^2= 0.952 predict that the service quality of e-voting technology contributed 96.4% to the performance of the 2015 general elections. The rest of the factors related to technology predicted 4.8% (0.048). The multiple linear regression model was determined using equation (1) below (Kilic, 2013):

$$Y= \beta o+ \beta_1 X_1+ \beta_2 X_2+ \beta_3 X_3+ \varepsilon \quad (1)$$

Where:

Y = Dependent variable (Election performance)

β_0 = Constant or intercept (value of the dependent variable at zero factors).

$\beta_1, \beta_2, \beta_3, \beta_4$ = Regression coefficients of independent variables.

X_1, X_2, X_3 = Independent variables (electronic voter data capture, vote cast assistive

technology, vote collating, vote safety and dissemination).

ε = Stochastic or disturbance term or error term.

The election performance was determined using regression equation (2) below:

$$Y= 0.141+ 0.287\ X_1+ 0.305\ X_2+ 0.235\ X_3 + 0.064\ X_4 \quad (2)$$

It is suggested that increase in the service quality of electronic technology for every activity of the electoral process may lead to increase in the level of elec-

tion performance. Therefore, the quality of automated electoral technology significantly influenced election performance in all federal states.

Conclusion

In conclusion, the application of electronic innovation was to deployed digital technologies by replacing it with e-voting. This is the innovations which governments try to engage citizens in a development initiative with strategic importance for upholding democracy in a society. However, some of the key findings of this study are summarized below:

1. The electronic technology performance was highly rated due to the significant influence on e-direct voter data capture, despite some quality concerns in some parts of the country. This may attribute to the failure occur on kits distributed without power or with no time for their charging.
2. Increase in service quality of this electoral technology led to increase in the level of election performance.
3. The finding shows that most required areas of improvement for election performance are electronic voter identification for vote casting, electronic voter data capture, electronic vote collating, and electronic vote safety and dissemination.

These electoral experiences did not happen by default but rather due to electoral technology differences. Besides, INEC, SIEC and external agencies should ensure that appropriate strategies are adopted to maintain, replicate and improve service quality reported about the following electoral bound electronic technology applications.

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[i] PVC stands for Permanent Voters Card

[ii] SCR is abbreviation for Smart Card Reader

[iii] NCSL in full is National Conference of State Legislatures