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Feasibility of Laying Fiber-Optic Cables underwater along River Nile Basin- Sudan Study Case

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Abstract: **-** Fiber optics cables offers various advantages of over regular cables when used as data transportation medium in today's communication networks. The River Nile basin countries such as Sudan enjoys vast distances that are travelled by the River Nile, offering a natural path for an underwater cable laying areas. In this study, the potential of laying such cables is investigated with Sudan taken as a case study. The socioeconomic impact analysis will be provided, and potential issues and obstacles will be discussed.

Keywords: **-** *Communications, Fibers, Network, Optic*

I. INTRODUCTION

Several researchers have provided detailed analysis of merits and demerits of using fiber-optic in communication network specially when long distances are involved where light suffers little attenuation compared to electric wiring cables. Examples of fiber-optics benefits includes[1]:

- Immunity to electromagnetic interference,
- Usage of nonconductive materials,
- No electromagnetic radiation from cables leading to high data security
- No current induced sparks risks since no conducting current is used
- Usage of small and lightweight materials
- High operating bandwidth over long distances.

Despite these benefits, the fiber-optic cables suffers from limitations such as[1]:

- Cost where cables are expensive to install but last longer than copper cables.
- Transmission where optical fibers require repeating at distance intervals.
- Fragility where cables are prone to breakage or transmission loses when wrapped around sharp curves. This can be avoided by encasing fibers in plastic sheath where cables will be hardened towards bending into a small enough radius that could result in fiber breaks.
- Protection **-** Optical fibers require more protection around the cable compared to copper.

Several researchers have reported on submarine optical fiber cable transmission systems and networks. Paul D. et. al. [2] provided analysis of undersea bed fiber optic cable network that is reported on several cable networks TAT, their cost, reliability, and system considerations. Furthermore, Iwamoto, Y. and Fukinuki, H.[3] have reported on submarine optical fiber cable transmission systems used during the 1985 in Japan. Recently, Aditi and Preeti [4] have published a study of submarine optical cables as a key component in undersea telecommunications. They proposed that submarine cables can also be used for purposes other than just underwater telecommunication. These include water reservoir monitoring needs.

Considering the fiber-optic network advantages and despite their disadvantages mentioned above, the fiber-optic cables are considered an effective alternative to use for new communication network in vast and spacious lands such as in Africa. This is in comparison to use of either satellite for telecommunication, or laying copper wire coaxial cables for long distances.

There are various projects that targeting linking Africa to world networks thru under water fiber-optic cable networks as listed in Table.1 and shown pictorially in Fig.1. Data presented in Table 1. and plotted in Fig.1 are extracted from [5]. However, it is a significant challenge to connectivity of inner towns and cities that are located far inland away from the coastal areas. Moreover, these towns and cities are sparsely distributed over a wide range of country lands with limited infrastructure to connect to coastal areas.

Table 1. List of undersea cables laid along Africa coastal areas.

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Africa Coast to Europe (ACE)
Asia Africa Europe-1 (AAE-1)
Eastern Africa Submarine System (EASSy)
Middle East North Africa (MENA) Cable System/Gulf Bridge International
Saudi Arabia-Sudan-1 (SAS-1)
Saudi Arabia-Sudan-2 (SAS-2)
The East African Marine System (TEAMS)
West African Cable System (WACS)
Africa Coast to Europe (ACE)

The Sudan, a River Nile basin country, represents a typical example of such situation in Africa. The eastern Red Sea coastal city of PortSudan (Fig.1) is linked to the undersea Eastern Africa Submarine System (EASSy), Saudi Arabia-Sudan-1 (SAS-1), and Saudi Arabia-Sudan-(2) (SAS-(2) network systems[5] while the majority of the Sudan cities and towns are located deep inland to the west of the coast.

There are various challenges that faces construction of fiber-optics ground cable networks within African countries in particular. Examples of these are:

- high cost of drilling operations to link the cables to remote places
- deliberate damage to cables and equipment with intention of theft and vandalism
- Land permit costs for areas that cable network is established on or passes through
- Adequate training of workers to properly install cables and equipment to prevent operational damages.

In this study, a proposal suitable for African River Nile basin countries to lay new fiber optics cable networks submerged under the river water level will be presented. The proposal addresses the challenges that are faced by common ground cable networks.

II. GEOGRAPHY OF RIVER NILE – SUDAN CASE

The River Nile is an impressive 6,853 km (4,258 miles) long and pass through an 11 African countries, namely Tanzania, Uganda, Rwanda, Burundi, Congo-Kinshasa, Kenya, Ethiopia, Eritrea, South Sudan, Sudan, and Egypt. The River Nile and its three tributaries (the white, the blue Nile, and Atbara river) when passes through the Sudan they create a complex web that connects many cities from various parts of the country as can be seen in map shown in Fig. 2. As seen from the map, there are several cities and towns that are located along the River Nile banks. Table 2. demonstrates a sample list of Sudanese towns with distances less than 100Km range that lie along the River Nile banks.

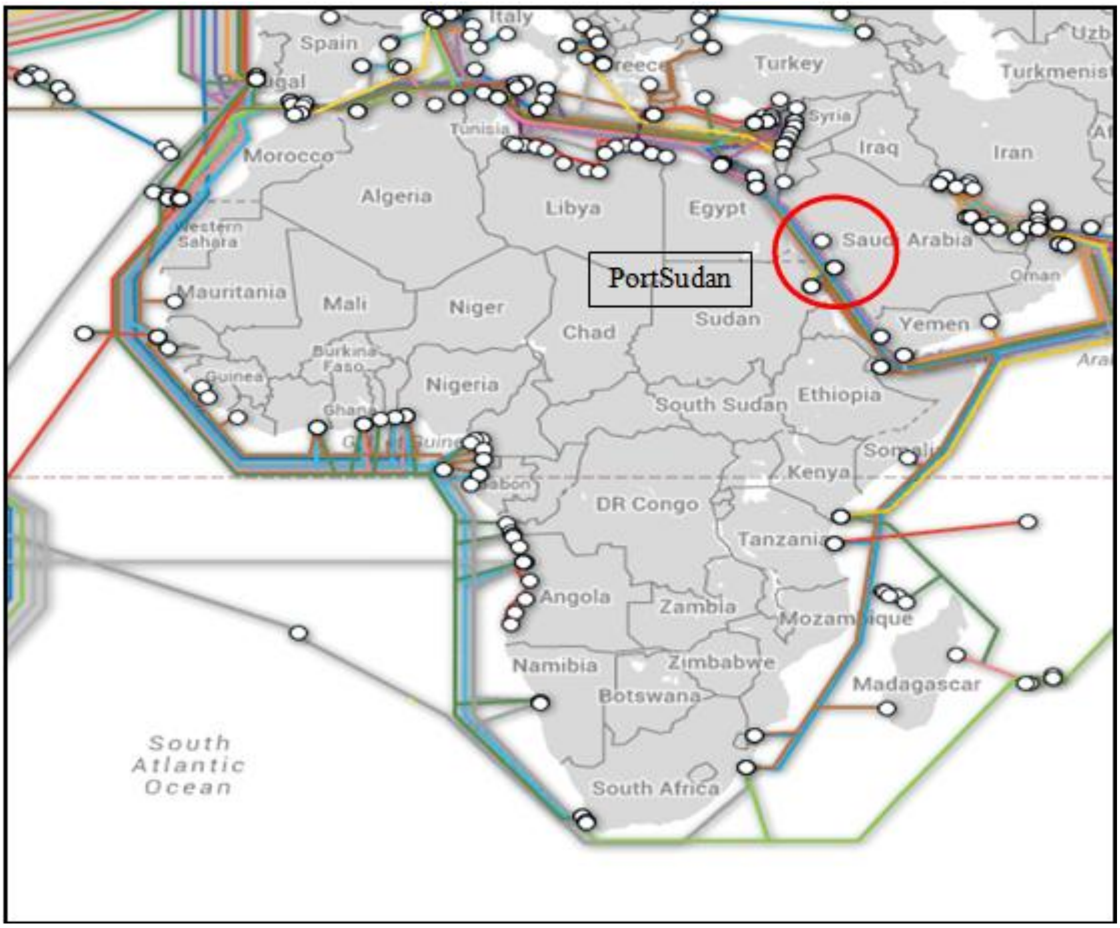

Fig. 1. Africa map with coastal undersea fiber-optic networks. Red Sea coastal city of PortSudan is encircled

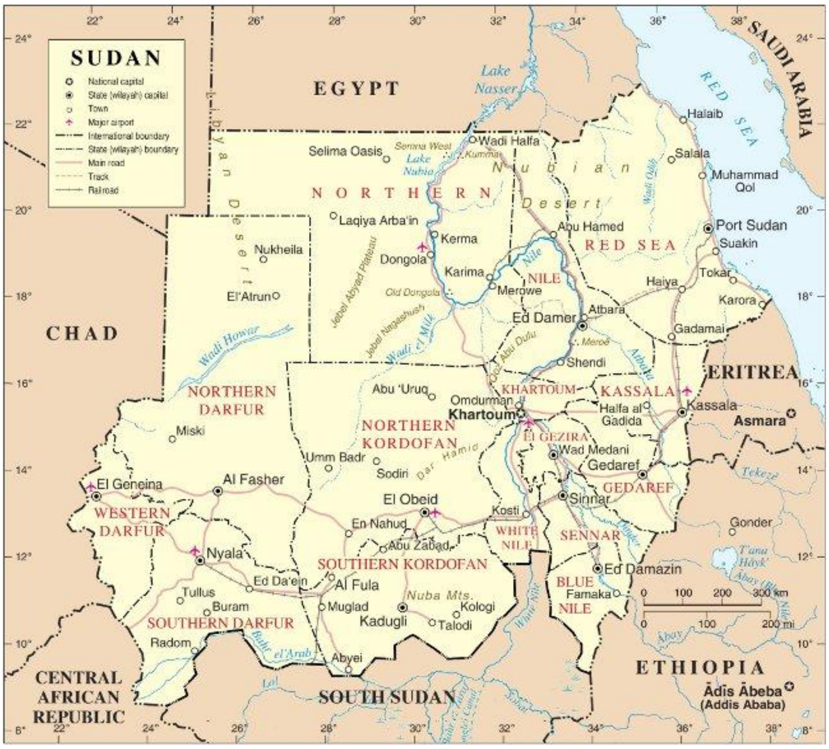

Fig.2 Map of the Sudan with provinces, cities, and path of the River Nile and its tributaries.

III. PROPOSED NETWORK INFRASTRUCTURE

The River Nile path provides a natural and safe pathway to lay a submerged fiber optic cables and connects into a network that would provide country wide coverage on relatively low cost premise. Table. 3. Shows a comparison between ground and submerged cables under River water.

Table 2. Sample list of cities/towns located along the River Nile banks and are within 100Km distances from neighboring cities.

#	City/Town	#	City/Town	#	City/Town
1	Wadi Halfa	14	AlBawga	27	Rofaa
2	Arab	15	Berber	28	Wad Madni
3	Dalgo	16	Atbara	29	Sinnar
4	Karma	17	Ad Damer	30	Singa
5	Argo	18	AlZidab	31	AlSuki
6	Dongla	19	Kaboshia	32	Ad Damazin
7	Al Dabbah	20	AlMatma	33	AlRosarus
8	Merowe	21	Shendi	34	AlGitaina
9	Karima	22	Khartoum	35	Ed Duiem
10	Korti	23	Alkhartoum Bahri	36	Kosti
11	Abu Hamed	24	Omdurman	37	AlJablain
12	AlShraik	25	Alkamleen	38	AlRank
13	Adahm	26	AlHasaheesa	39	Algandag
				40	AlFaki

Considering the aforementioned discussion, it would be beneficial to seriously consider constructing a fiber optic cable network through the River Nile course that would bring about connectivity to inland cities and town. Such network would enable connection of majority of river cities lies along the River Nile banks by laying segments of fiber-optic cables submerged at the bottom of the river corridor. Infrastructure would require construction of:

- control, monitor, and repeat centers along the river path for every 100km. This distance represent longest distance that can travelled by light thru these cables before repeating operations are required.
- Such control centers can also serves as check points for other essential services such as water level monitors during flood seasons and other public safety services.
- In the case when the river path through cities that are less that 100Km apart, only minor check points establishments will be required, resulting in large sums of infrastructure savings.

An analysis of cost, reliability, and system configurations of under river bed fiber optic cable network can be performed in a similar fashion of that by Paul D. et.al. [2] performed on under sea bed fiber cable networks.

IV. CONCLUSIONS

An overview of current status of fiber-optic cable networks in Africa is discussed. It was noted that the majority of the networks are established through submarine cables flowing over the coastal areas. Very little connections are constructed to connect inland and remote towns and cities. Moreover, the River Nile basin countries and river corridor review is also discussed. A proposal to utilize the natural pathway of the River Nile in the Sudan taken as an example to construct a fiber-optic cable submerged under river water. This would provide coverage to inland and remote areas that are located on or closer to river banks. A comparison chart of benefits of using river submerged cables versus ground cables is developed and presented. It was shown that for countries that are enjoys long river courses, this type of network can be used with significant advantages over ground cable networks. Such networks could serve as backbone of inter-African countries networks specially those are part of the River Nile basin.

Table 3. Comparison between ground and submerged cables under River Nile.

Factor	Ground Cables	Submarine Cables
General Costs	High	Standard
Land Cost	High	NA
Temperature	High impact	Low impact
Theft/Vandalism	Frequently	Hardly
Maintenance	Time consuming and costly	Fast and easy
Medium	ground	water
Human induced External effects	Behavior and Frequent	Negligible
Wars	Direct impact	NA
Security	Vulnerable	Immune
Monitoring	Costly and difficult	Cheap and easy
Repeaters	Standard Power grid	Station along River
Power	Standard Power grid	Station along River
Running cost	High	Standard
Service Continuity	Low	High
Materials	Standard	Standard
Earthquakes	High and direct impact	Low impact
Damage	vulnerable	immune

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