The Environmental and Social Impacts of Oil Exploration and Production on Melut basin of South Sudan.

LORO Emmanuel Ladu Legge*, Lu Zhibo**

UN Environment-Tongji Institute of Environment and Sustainable Development, College of Environmental Science and Engineering, Tongji University, Shanghai 200092 P.R China

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Abstract- In view of the environmental impacts of crude Oil exploration and production, it has caused more adverse impact than its beneficial desired end in the oil-bearing enclaves of Melut basin in the Republic of South Sudan. Crude oil exploitation has had and continues to have a deleterious impact on the environment in the region adversely impacting on the people inhabiting the area ever since its discovery in the 1970s. This review paper dwells much on the analysis of secondary source data such as gray literature, journals and primary data (field reports) on the environmental and social impacts of oil exploration and production on Melut basin. The Melut basin consists of a diverse ecosystem of savannah grassland, Machar wetland, and the Sudd wetland one of the Ramser sites in the heart of the African continent but due to oil pollution the area is now characterized by contaminated streams and rivers, forest destruction and biodiversity loss, in general, the area is an ecological wasteland as accidental and unmonitored oil spills take place. This affects the livelihood of the indigenous people who depend on the ecosystem services for survival leading to increased poverty and displacement of people. This review paper has identified some of the factors that have led to the fluctuation in oil production level in South Sudan as follows; (1) the secession of the South Sudan from Sudan in 2011, (2) dispute of transit fee with Sudan government on transfer tariffs of crude leading to a temporal halt of the flow of the crude oil in 2012 through the pipeline since the country depends on Sudan for the exports of its oil products to the port terminal in the Red Sea, (3) civil war (armed conflicts) between the ruling government and rebel factions that rebel right after the secession of the country and the 2013 crisis. (4) The shutdown of the Thar Jath oil procession plant and (5) the maturity of other oil wells and high level produced water than crude oil (6) accidental spills due to malfunctioning of the valves and malicious sabotage by individuals who against social welfare of the people. The review also shows that much of the oil spills occurring in the study area has limited/ to none reporting making it hard for quantification of the oil spills/lost, the pollution levels on land, water bodies and biodiversity are alarming. Here we also show that as much as oil is the desired product, during the production stage, a good amount of gas and produce water is produced as by-products in the due caused. South Sudan oil production is characterized by high level of produce water with limited treatment facility and a potential energy source (natural gas) is wasted or flared due to limited or no infrastructure for tapping and using this potential energy. The oil industry in this region has contributed immensely to the economic growth and development of the country in the recent past which is a fact that cannot be ruled out as the country heavily dependent upon but unsustainable exploration and production activities have severely threaten the ecosystem wellbeing of the region. We suggest that the Republic of South Sudan should employ the best technology to tap the product gas and to have a monitoring mechanism to detect oil spills and sound spills management system. Additionally, it is also evident that mud pits/ borrow pits have become a source and a habitat for disease-causing pathogens and pollution of water bodies. We also recommend that a combined technology of high efficient halophile oil-degrading microorganisms in biological treatment and membranes (SBR) biological treatment systems can be used for effective management of produced water since skimming and phytoremediation ponds/ lagoon are used for treatment which are less effective given the current produce water level and the acidity of the crude in the Melut basin.

Index Terms- Environmental and Social Impact, oil Exploration and Production, Paloich, Melut basin, South Sudan

I. INTRODUCTION

1.1. Background:

The exploration and production of oil and gas is a major industrial development and is regarded as a blessing. The sector is a major source of jobs and revenue for many oil producing economies globally. In August 1859, Colonel Edwin Drake drilled 70 feet well in Titusville, Pennsylvania, and discovered oil. By the end of 1800's a number of wells were drilled in Pennsylvania, Kentucky, and California. The birth of the modern oil industry is credited to the discovery of oil at spindle top in 1901 atop a salt dome near Beaumont Texas[1]. Oil spillage is a global issue that has been occurring since the discovery of crude oil which was part of the industrial revolution. Oil exploration was started in the then Sudan in 1959 but no oil, however, was found by the Italian oil company Agip after getting an offshore concession in the Red Sea area North - East from the Sudan government. It carried out seismic surveys and drilled six wells. Following Agip, western oil companies – Oceanic Oil Company,

Total, Texas Eastern, Union Texas and Chevron – moved in to search, but to no avail and most companies relinquished their concessions[2].

In 1974 Chevron took a 25% interest from Shell (Sudan) and was granted permission to search for oil. In 1978 Chevron found the first oil in the Muglad Basin which stretches deeply into Western Upper Nile in the South. In 1981 it made a second, more moderate find in the predominantly Dinka area Adar Yale in Melut Basin, east of the White Nile[3-5]. Four exploratory wells showed flow rates of 1500 and more barrels a day. Chevron believed there was a potential all the way south to Malakal and east to the Ethiopian border. In 1982 Chevron made a third, much large discovery at Heglig, 70 km north of the Unity field, home of the Nuer and began to develop Unity and Heglig oilfields.

In 1984 Chevron suspended operations and removed personnel, after the SPLM/A attack Chevron's base at Rub Kona, near Bentiu, killing three expatriate workers resulting into the splitting of Chevron's concessions into smaller units by the Khartoum government[4, 6]. In 1992, Melut Basin – Blocks 3 & 7 was awarded to Gulf Petroleum Corporation – Sudan (GPC) and in October 1996 GPC was able to drill and reopened Chevron's wells and built an all-weather road from Adar Yale to Melut. Adar Yale was inaugurated in March 1997 with a production capacity of only 5,000 b/d and 10,000 b/d in 1998 respectively. Adar Yale site was the first site to produce crude oil to be exported using trucks from Adar Yale to Melut then by boats to Khartoum.

In 1997, Greater Nile Petroleum Operating Company (GNPOC), a consortium of China, Malaysia, and Sudan, built a 1540 km oil pipeline from the oilfields to a marine export terminal on the Red Sea[7-8].

On 31 August 1999, the first 1,500 barrels of crude oil traveled through the pipeline to be loaded onto a tanker which sailed for refineries in the Far East. Oil production and export have increased steadily since then and new discoveries have been made. In 2003 the China National Petroleum Corporation (CNPC) announced the discovery of a "world class" oil field in blocks 3 and 7 east of the White Nile, oil production was on average 270,000 b/d and 304, 000 b/d in 2004 respectively[7].

The signing of the comprehensive peace agreement (CPA) in January 2005 between the government of Khartoum and the Southern Armed forces (SPLA) ending to the long civil war had improved conditions for oil production and export. However, the CPA culminated in a referendum with a 98.8 % votes for succession. And in 2011, the Republic of South Sudan has officially declared as a sovereign country. With the development of the oil sectors, oil industry is seen as one of the most contributing sectors that will improve on living condition of the citizens and after the succession of South Sudan from Sudan, it inherited most of the oil wells which gave raise to high expectations from the South Sudanese as a catalyst for high income and wealth creation and others were apprehensive because no oil producing country with a history of inland or of offshore hydrocarbon has escaped the negative impacts of the sector on the Environment and the socio economic activities of the host communities.

II. Materials and Methods

2.1. Study area:

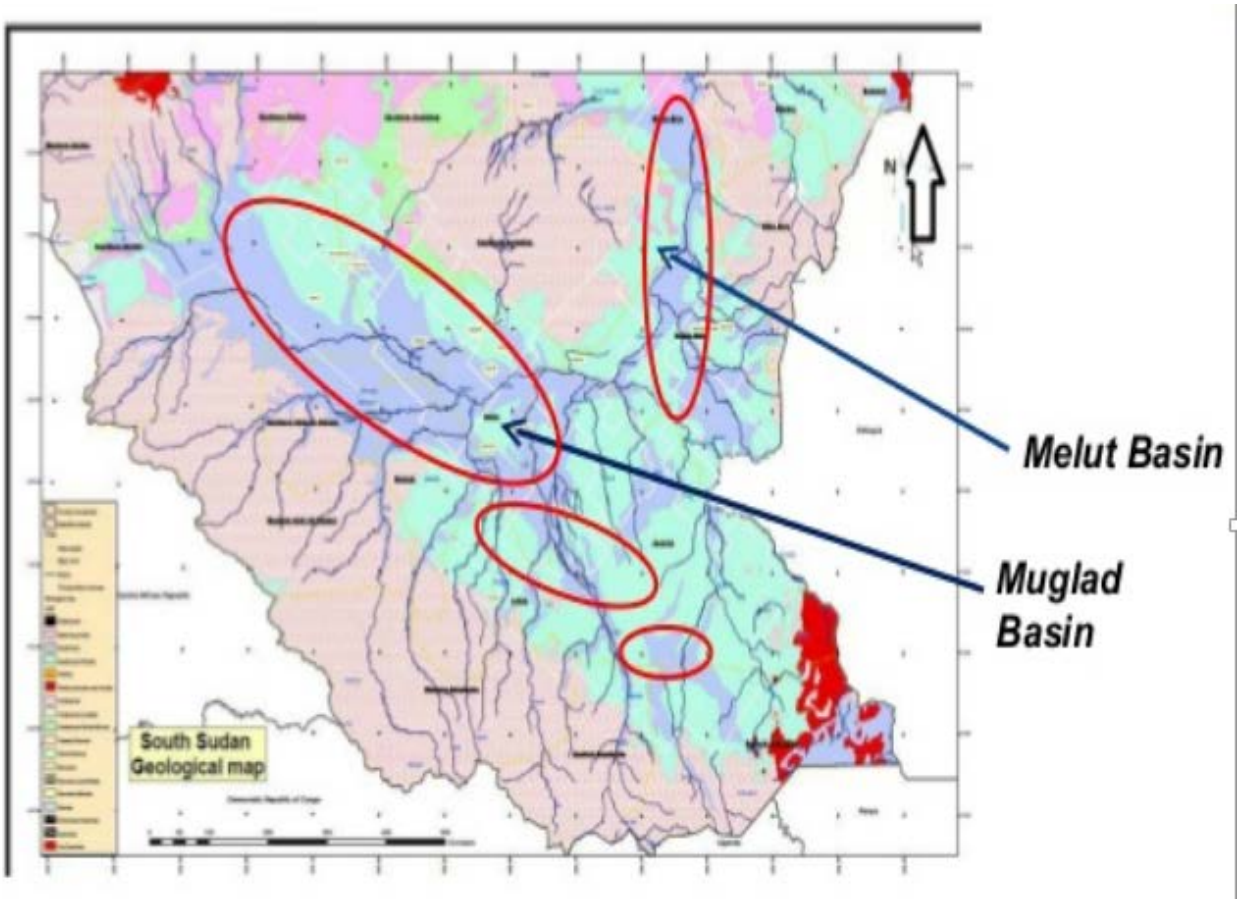
South Sudan gained independence from Sudan in July 2011. Most of the oil production capacity is now in South Sudan, but the country is landlocked and remains dependent on Sudan because it must use Sudan's export pipelines and port.

The Greater Upper Nile is a region of northeastern part of the Republic of South Sudan with its capital Malakal, the region comprises of Unity, Jonglei, and Upper Nile.

The Melut basin is one of the counties of the northern Upper Nile region, South Sudan. The Melut basin is remote and it lies on the northernmost edge of South Sudan. The oil development in blocks 3 and 7 falls under Melut basin and has so far not been publicly scrutinized due to it being marginalized by the civil wars and the current conflict in the country. Oil development in northern Upper Nile is concentrated in Melut County and Maban on the plain east of the White Nile, which hosts one of the world's largest and best-conserved wetlands, the Machar marches. The oil works cut right through it, from Melut to the Sobat River, 200 kilometers further south on the Ethiopian border.

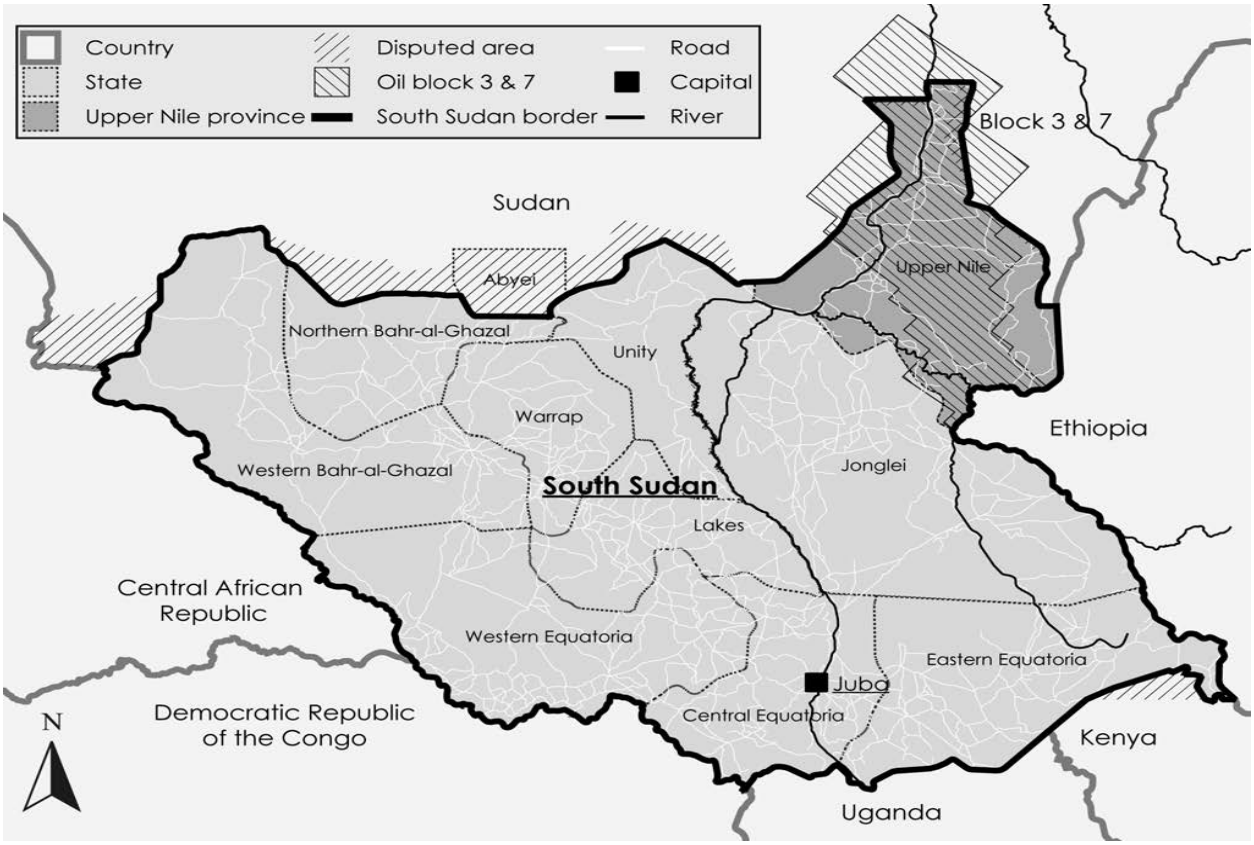
Melut and Maban counties are part of a flat clay plain with seasonal streams (Khor) running from the east to the White Nile in the west. The climate is hot and the area is swampy in the rainy season, between June and October, and increasingly dry during the rest of the year. The inhabitants are predominantly Dinka and Maban agro-pastoralists and non-Muslim. They mostly live by herding, cultivation, and fishing. During the wet season, they stay in permanent settlements on the slightly higher ground, for the most part, small sandy ridges, surrounded by the black clay soil that floods and is not fit for settlement. A village in this area would typically count between 200 and 500 inhabitants. There are also numerous smaller settlements, sometimes with a handful of "***tukuls***" only. In the dry season (i.e. from October to May) the land becomes parched hence pastoralists move their herds toward the river for water, to graze on and for fishing ground. While in wet seasons, they move to higher ground. Although Melut basin is one of the richest oil areas, northern Upper Nile is very poor and is characterized by lack of infrastructures such as schools, health centers, paved roads, portable drinking water infrastructures, poor hygiene, and sanitation.

Map 1. 1 South Sudan Basin



Source: **MPM, 2012**

Map 1. 2. Republic of South Sudan and Oil Blocks 3 & 7 in Upper Nile Region



Source: **ECOS, 2007, Geonames, 2012, Natural Earth Dataset, 2012, MPM, 2012**

2.2. Data Sources

The study review of oil exploration and production at Melut Basin in Greater Upper Nile and its impact on the Environment was developed through analysis of secondary source data. These sources include reviewed materials present in the journal, books, national presentations, supplemented by non-peer reviewed literature from a wide range of other sources, including international and non-governmental organizations, and some commercial organizations. These sources were collected through comprehensive and extensive literature search using academic reference databases including Web of Knowledge, Science Direct and Google scholar (including databases such as aquatic science, conference papers index for life, Environment and Aquatic science, GeoRef, International Bibliography of the Social Science, Oceanic Abstracts) were all used to identify relevant literature and articles in the news line from the country. This review involved obtaining data from the past and present studies, and current literature including field reports. The study relied on secondary data, and the data were analyzed using descriptive methods to obtain logical deduction and sequential presentation of facts from the data obtained that gave a precise picture of the subject matter.

2.3. Petroleum and other Natural Resources

Oil remained the world's leading fuel, accounting for a third of global energy consumption. Oil gained global market share for the second year in a row following 15 years of declines from 1999 to 2014. According to BP, the Dated Brent oil price averaged $43.73 per barrel in 2016, down from $52.39 per barrel in 2015 and its lowest (nominal) annual level since 2004. Global oil consumption growth averaged 1.6 million barrels per day (Mb/d), or 1.6%, above its 10 year average (1.2%) for the second successive year. China (400,000 b/d) and India (330,000 b/d) provided the largest increments[9].

Global oil production, in contrast, rose by only 0.4 Mb/d, the slowest growth since 2013. And production in the Middle East rose by 1.7 Mb/d, driven by growth in Iran (700,000 b/d), Iraq (400,000 b/d) and Saudi Arabia (400,000 b/d). Production outside the Middle East fell by 1.3 Mb/d, with the largest declines in the US (-400,000 b/d), China (-310,000 b/d) and Nigeria (-280,000 b/d)[9].

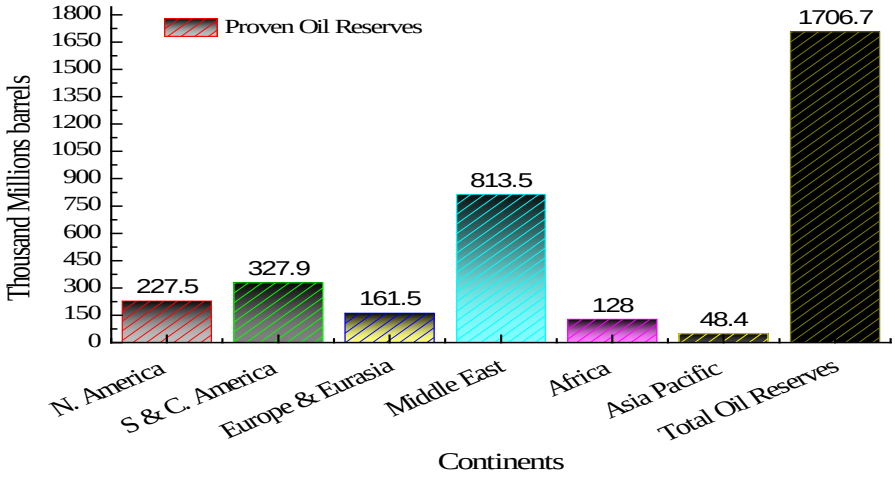
Refinery throughout growth slowed from 1.8 Mb/d in 2015 to 0.6 Mb/d last year. Refining capacity grew by only 440,000 b/d, versus 10-year average growth of 1 Mb/d, causing refinery utilization to rise[10].

Table 1. Proven oil reserves

Continents	Total proven oil reserves (Year)		
	1996	2006	2016
North America	127.3	221.7	227.5
South and Central America	90.7	110.8	327.9
Europe and Eurasia	142.8	137.6	161.5
Middle East	674.0	755.9	813.5
Africa	74.9	116.9	128.0
Asia Pacific	39.0	45.5	48.4

Source: ***BP report, 2017***.

Total proven oil reserves



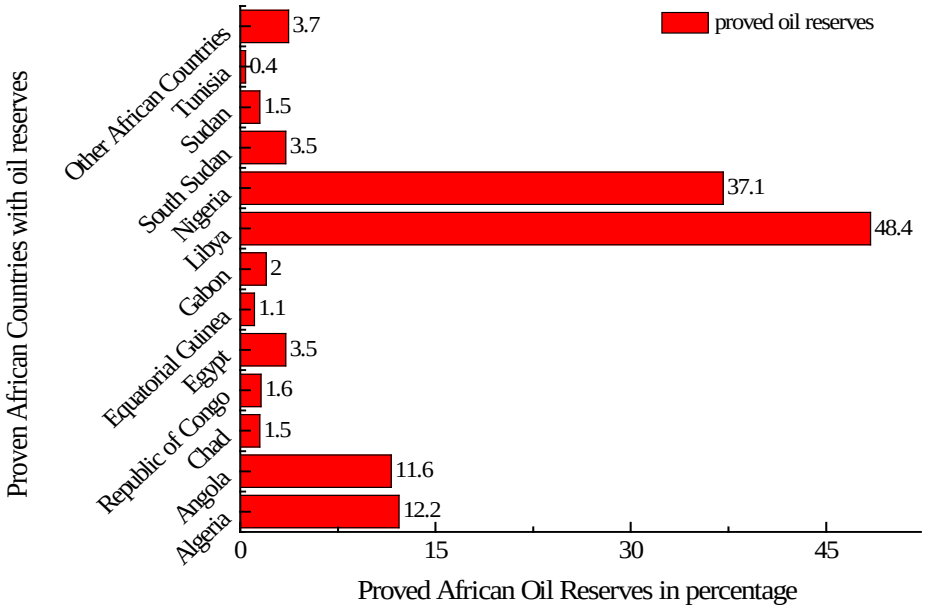
Source: **BP, 2017**

Africa is rich in natural resource ranging from arable land, water, oil, natural gas, minerals, forests, and wildlife. The continent holds a huge proportion of the world's natural resource both renewables and none-renewables[11].

Africa is home to some 30 percent of the world's minerals reserves, 8 percent of the world's natural gas, 12 percent of the world's oil reserves; the continent has 40 percent of the world's gold and up to 90 percent of its chromium and platinum. The largest reserves of cobalt, diamonds, platinum, and uranium in the world are in Africa.

According to the oil and Gas Journal (OGJ), South Sudan had 3.5 billion barrels of proved oil reserves, as of January 1, 2014. Accordingly, the majority of the oil reserves are located in the oil-rich Muglad and Melut basins of which currently Melut basins is the only operating oil field in South Sudan because of civil conflict and it does produces the Dar blend Crude oil which is sold at less compared to the Nile blend of the Muglad oil fields.

Natural gas associated with oil fields is mostly flared or re-injected. Despite proved reserves of 3 trillion cubic feet, gas development has been limited in South Sudan. The Republic of South Sudan produce natural gas around 368,417 and are accordingly being flared.



Source: **BP, 2017**

2.4. Environmental implication of oil exploitation/production

2.4.1. Oil exploitation and production

It is referred to a process in which usable petroleum is extracted and removed from the ground. It involves seismic activities resulting into the degradation of the environment in form of depletion, oil spills, and deforestation without due consideration to its regeneration to the impoverishment of the host communities[12]. Both exploration and exploitation degrades the environment in varying capacity and they are used interchangeably in this work across the globe.

2.4.2. Impacts of gas flaring on air quality

Gas flaring is the process of separating and burning of the gas produce during oil resources extraction from the ground. In countries like the Republic of South Sudan that lacks the technological advancement to tap the product gas, burns the produced gas in a massive flares as waste and are release into the atmosphere (into the air/ environment) without giving due consideration of its effects in the environment[13]. Gas flaring without temperature or emissions control pollutes the air and released unacceptably high levels of carbon dioxide into the atmosphere for example in the Niger Delta, an independent study have revealed that 75% of gas is being flared and contributes to air pollution[14].

Environmental degradation is critical because the ability of the environment to support and sustain life depends on the proper natural balance of its parameters such as the water, air, soil, flora and fauna, temperature, oxygen for the sustenance of life on the life-supporting planet.

Oil exploration and production involve various chemical and seismic wave generation is a major source of environmental degradation particularly through liquid discharges and oil spills as well as gas flaring. Petroleum renders the soil infertile, burns vegetation and kills useful soil microorganisms thereby hampering agricultural productivity[15]. Accordingly, before mineral resources are harnessed, they pass through the stages of exploration, mining, and processing; different types of environmental damages and hazards inevitably accompany these three stages of mineral development[16].

Oil spills (either in crude or refined form), natural gas flaring and deforestation which are highly associated with oil extraction are common phenomena in the oil communities and have caused severe environmental degradation in the oil-producing enclaves this is because they contaminate the environment, cause water and land pollution with grave consequences on both human and natural environment due to the toxic nature of the chemical discharged as it is in the case of Niger delta[17-18].

2.4.3. Effluent and Waste discharges on soil

Another source of oil related pollution is the discharge of effluents into the surrounding environment, sometimes into the water, by the oil companies.

Oil production has a significant impact on the landscape and local environment. Contamination of soil and water is a major common consequence of oil production, particularly in areas with nonexistence or not enforced environmental regulation. For example in Ecuador, oil and water separation stations in the Oriente generate millions gallons of effluents each day, most of which are discharged untreated into the environment[19]. Groundwater is particularly susceptible to high contamination from the produced water and other uncontrolled chemicals during oil drilling. These effluents contained contamination of both oil fractions and heavy metals

Oil spills are a major concern, according to the Ecuadorian government, the trans- Ecuadorian pipeline has spilled about 17 million gallons of oil since it began operating in 1972. This has not only impacted on the environment directly but raises the potential as well for both surface water and underground water. In a country like South Sudan, the potential for accidental leakage and intentional leakage from skirmishes has not be assessed and it should be noted however that most of the south Sudanese people and their livestock in the area and beyond, depending on the untreated water of the river Nile for their domestic needs.

For instance, during exploration or seismic surveys by oil companies, drill cuttings, drilling mud, and fluids are used for stimulating production. There is also the use of chemicals during seismic activities. The major constituents of drill cuttings such as baryotes and bentonitic clays and the production of unusually high total acid values (TAN, up to 10.4 mg KOH/g oil)[20] when dumped on the ground prevent local plant growth until natural processes develop new topsoil. In the water, these materials are dispersed and sink and may kill local bottom living plants and animals by burying them[21]. In addition to the pollutants introduced into the environment from exploration and exploitation operations, refinery wastes also have characteristics which constitute potential land, water, and air pollutants[22]. The disposal of wastes into the sea from oil facilities has direct effects on fish stocks and other microorganisms.

2.4.4. The impact of oil exploration and production on Paloich biodiversity

The most profound and adverse impact of oil pollution in Paloich with far-reaching implications on all other aspects of our traditional lifestyles and livelihoods had been the total loss of biodiversity and destruction of habitats largely due to soil degradation[23] as this affects the right of animals and the unborn generation[24].

The results of the unchecked oil pollution in Paloich as in many parts of the world have been the complete destruction of ecosystems, the savannah grassland and the flat plains has fallen to the axe of oil companies, wildlife and game have been driven away and farmlands have been rendered infertile with gross implication on the right to adequate food[25].

During oil spills, the process of photosynthesis which enhances plant diversity is impaired since the process is reduced due to the fact that spilled crude has a high absorbance property so when the crude spreads on to the surface of leaves, the latter find it difficult to photosynthesize and thus die, leading to biodiversity loss.

The toxic crude also affects underground herbs and shrubs, while microbial organisms which form important groups in the food web are also destroyed, this phenomena is evident in the uncheck oil pollution[26] as it is in case of Paloich area as the dark blend crude oil is acidic in nature.

The oil industry, especially the exploration of oil has destructive environmental impacts, according to kadafa [27-28] destruction of the environment is referred to as engendering ecological balance. Oil extraction involves several environmental pollution processes. Extractive activities can have a profound social and economic impacts[18]. They can have a positive effect on the development by creating jobs, encouraging business and providing vital infrastructure for remote communities such as roads, electricity, education and health. Oil exploration and production impacts on the environment in many negative ways by exposing it to oil leakages and spills, gas flaring and deforestation as a result of the creation of access routes to new areas[18]. The environmental pollution associated with oil exploration and production has serious implications for the survival of species in communities near/ within oil reserves.

2.5. Impact of oil exploration and production activities on Socio- Economic conditions

2.5.1. Nutritional styles and Food Shortage

Oil production all over the world is associated with oil spills or pollution which may have health implications for human lives from consuming contaminated water as leakage of carcinogenic compounds gets their way into water bodies[29]. An empirical research also links oil activities to fever due to heat generated by gas flaring activities as produce gas are flared on daily basis.

Various disorders are contracted through the consumption of polluted water from water bodies in oil producing communities, a report published by a German aid agency “sign of hope” (sign of hope) revealed high level of lead and barium found from the hair samples taken from volunteer living around Thar Jath oil processing plant in South Sudan[25, 30]. This shows that there is a direct link between the contamination of the people and the activities of the petroleum industry working in the Republic of South Sudan.

Crude oil exploration and production often lead to greater social consequences than other forms of development induce socio-economic disruption hence affecting the communities’ livelihoods[31]. Oil exploitation, in the Eastern Upper Nile region and the connected construction of a pipeline, led to the burning of 48 enclaves and displacement of 55,000 people, the worst situation was in Bentiu and Rub Kona regions there was a massive forceful eviction of the populace causing social disruption and loss of livelihoods[31]. According to the United Nation Report in September 2001 more than 100,000 people were displaced between 1999 and 2001[2]. The environmental pollution caused by oil drilling also results in a destruction of livelihoods in local communities making it difficult for the present and future generations to make a living off of their land.

Farming activities, as the mainstay of these economies, literally grind to a halt with the exploration of oil.

One fallout of oil pollution in the Paloich area is the destruction of the traditional local economic support system of fishing, farming, and livestock rearing.

The combination of the effects of the oil spill and acid rain resulting from gas flaring has been soil degradation which affects crop yield and harvest as it is in the case of the Niger Delta[32]. The ultimate result of this is the poor crop yield as the soil has been rendered infertile and poor fish catch, as most fish has been driven into deep waters and the indigenous people do not have an alternative source of balanced diet. The whole impact of this is the food shortage and which has affected the ability of most families to feed themselves.

2.5.2. Destruction of Traditional Means of Livelihood

Another implication of oil pollution is that having destroyed biodiversity, it has also rendered the agricultural sector, which is the largest employer of labour in most of the world's wetlands for example in the Niger Delta, environmental change of the wetlands are due to oil exploration and exploitation resulting into loss of its valuable services[33]. In the flat plains, much of the wetland is threaten with the oil activities and thus may render the wetland unprofitable to the local communities rendering most of the youth and women jobless since their local economic support system of pastoralism and farming is no longer sustainable.

An example is the case of the swampy flat plains of the Greater Upper Nile Region where the livelihood of the local people have been sustained by living in the midst of a once healthy and productive swamp by fishing, farming and green pastures for animals feeds. They also gathered papyrus for making mats and for local energy and fuel. However, due to it being subjected to ceaseless oil spill incidences, oil have coated the breathing roots of this plant killing off parts of the vegetation, animals and aquatic life that depend on it yet this accidental spills are unaccounted, remediated and reported.

This flat plains and the swamps which serve as habitats for fish and other microorganisms, as well as a source of raw materials for communities in Paloich have been lost to the ravages of oil pollution. The land, the water, and the environment can no longer support the subsistence life that this local Paloich community, which they have been dependent upon for thousands of years.

2.5.3. Migration and the Rise of Environmental Refugees

Socio-culturally, the Paloich people live in closely knit communities and are more endogenous. The Paloich people were not used to mass outflows/movement from their territory as their subsistent economy provided them with their basic needs. To the average indigenous people, movement from the area, which was considered a place of abundance into alien lands, means subservience, poverty in the new area, and loss of pride and self-esteem and it is only being practiced in the search of greener pastures for cattle exposing them at risk as cattle wresting among the cattle herders in South Sudan is inevitable.

But due to the discoveries of available commercial crude oil reserves in the area in the early 1970s, Oil pollution has resulted in the destruction of the Upper Nile Region environment. This, in turn, has led to the unsustainability of land for the traditional economic livelihood patterns that once thrived in the area[34]. As a result, there are many women and youth immigrating out of the area into cities especially to big towns like Malakal, Rent and Juba while the disable are left in the wilderness, where they have become environmental refugees and because of their poor economic status, have had to take up accommodation in shanties, slums and watercourse with its attendant risks especially in terms of rights protection.

2.5.4. The Impact on Cultural Values and Spirituality

Oil spills and Gas flares know no boundaries so there are adverse impacts on cultural values and social harmony. One of the most telling impacts of oil pollution on the Paloich community is that it has led to the death and possible extinction of medicinal plants and herbs that are rooted in our traditional medicine and spirituality that have deep spiritual significance to the community. This degradation is brought about by the fact that most of these herbs and plants are found in sacred places of worships (***Ngundeng shrines***), which have fallen under direct destruction in the course of oil exploitation and the toxicity of oil pollution.

2.5.5. Impact on Traditional Institutions of Authority and Social Harmony

One area in which oil pollution has dealt a death knell to our customs and traditions is the rugged individualism which it has fostered amongst members of our communities which is contrary to our communal lifestyles as this has resulted into the disintegration of customs, traditions and social values, such as respect for our elders.

By the Dinka tradition (a common practices among the tribes in the whole of South Sudan), elders are given the traditional authority to be custodians of the community and its protectors in times of stress and inconvenience such as during oil spills and other environmental incidents.

The traditional system ensures that no single individual has the right to take what belongs to the community for him or herself. However with the arrival of the oil companies, a new level of relationship is created between the oil companies and the elders led by the traditional rulers who most times now see their community people as subjects and them as big men because of the largesse and special treatment that are given to them (individuals rather than the communities) by the oil companies thus alienating them from the people.

The result is that in times of distress or oil pollution like oil spills and fire conflagrations, most of these elders think of themselves first and collect monies and others from the oil companies or them will form companies in order to front them for contracts to do the "clean up exercises" which are actually euphemisms for "cover-ups".

Rather than being the supposed protectors of the people, most elders are being seen as collaborators with the oil companies thereby eroding community respect for their status and subsequent conflict between them and the youth. In this way, the social harmony that once existed is broken and discord ensues.

III. Results and Discussion

The presence of substantial amounts of oil and gas reserves has been identified by many authors as a potentially mixed blessing for oil producing countries[34-36]. Although the discovery of oil creates a sense of hope and expectation that the revenue would lead to the development of local communities and country as a whole, in most cases, this expectation has remained illusory as the exploration and production of the oil resources has led to the destruction of local communities livelihoods and the environment in oil-producing developing countries. Evidence around the world suggests that whether or not a community/ country benefits from its discovery of oil and gas is a function of the global position of the oil-producing country in question[37]. In most cases, local communities and oil producing nations in the highly developed countries seem to derive more blessings from the oil discovery and exploration in comparison to those in the less developed countries. A typical example in this regards is Norway which was the poorest country in Scandinavia at the end of the 1960s but had by the end of 1990 become the wealthiest, this was attributed to oil discovery in late 1969. Larsen [38] attributes this success to Norway's ability to prevent rent-seeking and corruption which have been identified as core elements of the resource curse key elements of Norway's success include the existence of policymakers and politicians who had refrained from dipping their hands into the government pool, a highly efficient judicial system that prosecutes the few defiant rent-seekers in an expeditious manner, a transparent reporting system that provides information to every Norwegian citizen about exactly how much revenue has been generated from the oil industry via both newspapers and the internet as well as a strong media that serves as a watchdog. But in the Republic of South Sudan context, this has not been the case especially after it inherited most of the oilfields from Sudan right after the secession through a peaceful referendum in 2011 with less to limited experience in the management of such industry.

2.6. Oil sector Management

National oil companies from Asia dominate the oil sectors of South Sudan and Sudan. The China National Petroleum Corporation, India's oil and Natural Gas Corporation and Malaysia's Petronas hold large stakes in the leading consortia operating oil fields and pipelines. National oil companies Sudapet (Sudan) and Nile pet (South Sudan) also hold small stakes in operations.

South Sudan enacted the Petroleum act 2012 and Petroleum Health, Safety and Environmental Management System and Plans Regulations 2015 which outlines the institutional framework governing the hydrocarbon sector. The act established the national petroleum and gas corporation (NPGC)[39]. NPGC is the main policy-making and supervisory body in the upstream, midstream and downstream segments of the hydrocarbon sector and is authorized to approve petroleum agreements on the government's behalf. The Ministry of Petroleum (MoP) is responsible for the management of the petroleum sector.

The Sudan national petroleum corporation (Sudapet) is the national oil company in Sudan and the Nile Petroleum Corporation (Nilepet) is its counterpart in South Sudan. At the end of 2011, South Sudan nationalized Sudapet's assets in the south and transferred them to Nilepet. Both companies are active in their respective country's oil exploration and production and are often minority shareholders in production sharing contracts with foreign oil companies because of their limited technical expertise and financial resources contrary to the section 81 of the Act.

Table 2. Main Oil companies in South Sudan

Consortium/Subsidiary	company	Country of Origin	Share (%)
Greater Nile Petroleum	CNPC	China	40
	Petronas	Malaysia	30
	ONGC	India	25
	Nile pet*	South Sudan	5
Dar Petroleum Operating company (DPOC)	Petronas	Malaysia	40
	Nile pet	South Sudan	8
	Sinopec	China	6
	Nile pet	South Sudan	41.9
Sudd Petroleum Operating company (SPOC)	Petronas	Malaysia	33.9
	ONGC	India	24.1
Star Oil	Ansan Wikfs	Yemen	66

Note: *Nile pet is the main national operating corporation in South Sudan.
Source: *www.dev.eia.gov/countries/analysisbriefs/sudan*

2.7. Oil production in South Sudan

South Sudan has experienced frequent disruptions to production over the past few years. In January 2012, the country voluntarily halted its production because of a dispute over transit fees with Sudan. South Sudan's production was partially shut down again at the end of 2013 because of civil conflict[40].

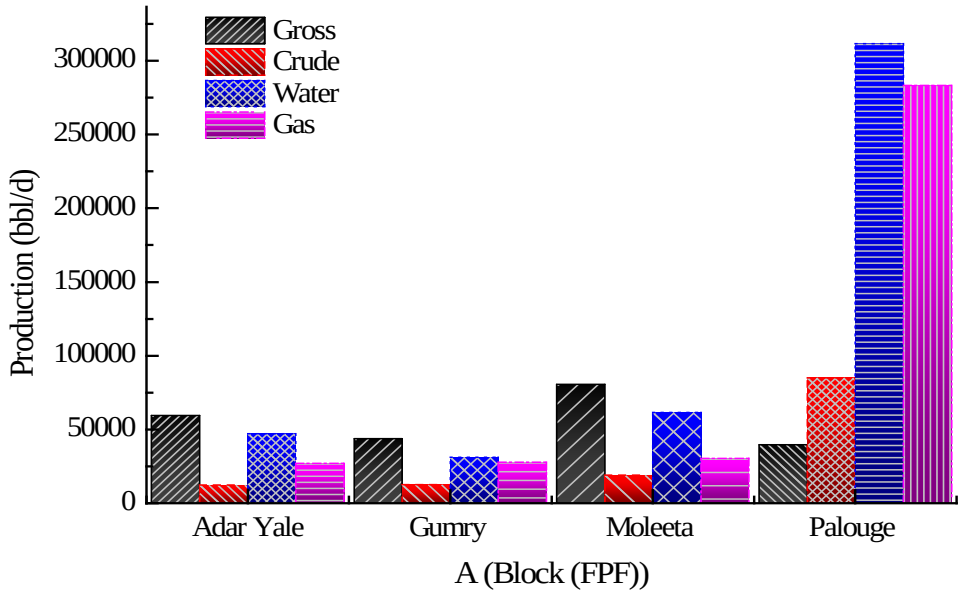
For the first half of 2014, South Sudan's oil production average 260,000 barrels per day (bbl/d), down from almost 490,000 bbl/d in 2010[41]. Disagreements over oil revenue sharing and armed conflict have curtailed oil production over the past few years. Also, the oil fields in the country are mature, and output has naturally declined compared to the previous years. South Sudan's production averaged 129,193 bbl/d per day as of 2017 down from 245,000 barrels per day before the 2013 crisis. However, the country plans to get the industry back on track with a production target of 290,000 barrels per day for the 2017/2018 fiscal year[42].

For the first time in 2017, South Sudan is attracting new oil companies to its acreages and with around 70% of the country unexplored, the country's large and somewhat virgin territory represents huge hydrocarbons potential, as it can be witness by the signing of Nigerian based Oranto Petroleum in early 2017 to explore and produce oil in the country with an investment worthy $500 million dollars in Block B3 of the Unity State oil fields[42] as this will increase the current production level from the Melut basin of Block 3 and 7 which are now producing almost 90% water as evident from the field report.

Table 3. Oil production statistics in South Sudan's Melut basin (Block 3 & 7).

Block (FPF)	Daily Crude Production			
	Gross (BBL/D)	Crude (BBL/D)	Water (BBL/D)	Gas (M^3/D
Adar Yale	59571	12448	47123	26918
Gumry	43862	12652	31210	27850
Moleeta	80571	19106	61465	30304
Paloich	39660	84987	311653	283345
Total	**580644**	**129193**	**451451**	**368417**

Source: **DPOC 2/2018, MoP/RoSS 2018**



This disruption estimates take into account adjustments to South Sudan's effective capacity and assume that a portion of pre-shut in production was compromised because of technical issues surrounding the shut in and its duration. Thus even if there are no production outages in South Sudan, the country's production cannot recover to its pre shut in 2011 average level of 340,000 bbl/d at least in the near future because of permanent damage and natural decline, particularly at mature fields in Unity state and currently all of the oil being produced in South Sudan originates from the Melut basin (Blocks 3 and 7) which has also impacted on the production level, where by less crude oil is produce than produced water.

Natural gas associated with oil fields is mostly flared or re-injected. Despite proved reserves of 3 trillion cubic feet, gas development has been limited in the Sudan and South Sudan. In 2016, the proved natural gas estimates was 503.3 trillion cubic meter of potentially available gas in Africa (39.3 trillion cubic meters in other African countries)[9]. In 2016, Africa produces 208.3 billion cubic meter of natural gas is being consumed and the resultant 70.1 is flared as it is evident in South Sudan that produces around 368417 cubic meter of natural daily as it is evident from the field report adding to the global average of flared gas in 2008 which was estimated at 139 BCM[43], resulting into an elevated total carbon dioxide emission from 422.9 to 426.6 cubic meter, a remarkable increase of 1.3 %[9].

It is also evident that most of the gas production with the crude oil is being flare hence rising concerns about the environment and human health with less or without any due consideration. However efforts have not been made to effectively tap the produce gas for other uses, they are being flare or re-injected to recover oil. Additionally, the majority of South Sudanese depends solely on fuel word as a primary energy leading to a massive deforestation and increase greenhouse gases in the atmosphere since less trees are left that acts carbon sink thus it could have become an alternative source of energy if tapped and supplied to homes for domestic use.

2.8. Health and conservation implications of the oil industry

The presence of oil infrastructure per se is known to lead to a wide range of environmental impacts[44]. Oil spilled on terrestrial environments will undergo volatilization and biodegradation. On soil, a significant fraction will infiltrate into the subsurface and remains there while the remaining oil fraction with heavy molecules have attracted significant concern due to

carcinogenic potentials and the ability to bio accumulate[45]. Thus the effect of the oil spills on ecosystems is detrimental to both humans and wildlife through the food chain since degradation of such hydrocarbon pollution or the recovery of a polluted medium such as the soil is slow[46] as witness in Paloich oil fields.

2.9. Effect on Underground Water

A serious threat posed by oil-related pollution is the impact on both surface and underground waters. When oil spills occurs or when there is an effluent discharge, it seeps into the ground and becomes mixed in the underground water system[47]. It has been found that polluted underground water take many years before it can be remedied. Yet this underground water moves into streams and wells which are the only sources of local water supply in the community which results in the rise of water-borne diseases. This has affected the traditional relationship of the people with water in the oil bearing enclaves. There is a perceptible fear that rather than being the source of life, these water systems have become sources of misery, disease and death.

South Sudan oil production is characterize with low oil productivity due to the maturation of the fields and thus crude oil production as seen from the field report is characterized with a high level of produced water of which only a portion is re-injected into the wells for oil recovery process.

Table 4. Total produced water

Block (FPF)	Daily (bbl./d)	Monthly (Mbbl.)	Yearly (MMbbl)
Adar Yale	47123	571.94	2,132.94
Gumry	31210	380.62	1,382,86
Moleeta	61465	711.14	2,542.65
Paloich	311653	3,734.59	13,271.09
Total	**451451**	**5,398.30**	**19,329.54**

Source: **DPOC 2/2018/ MoP/RoSS/ 2/2018**

Operational discharges from the oil industry have created public concern because they represent a very large continuous input of contaminants to the environment from many widely dispersed point sources. According to the American petroleum institute, about 18 billion barrels (bbl) of produced water was generated by U.S onshore operations in 1995. A large volume of produced water is generated at the Melut basin oil fields on a daily basis which post a threat to the life since apparently there is not effective treatment at the site.

IV. Recommendation

To minimize environmental risks in a wet and swampy area of the Melut basin, requires adequate technology for resource recovery, ambitious and clear standards and procedures, their integration into effective management systems and commitment from the highest management to curb the environmental pollution taking place.

There should be a continues Environmental impact assessment and a periodic Environmental Impact Statement defining the State of the Environment of the local area.

It is also evident that most of the gas production with the crude oil is being flared hence rising concerns on the environment and human health with less or without any due consideration, tapping of gas production with oil will proof to be a potential source of energy, the development of gas infrastructure for the treatment of produce gas into a compressed or pipe gas is strongly recommended as this will provide a potential energy source that can be consumed locally minimizing/ reducing the alarming rate of deforestation in search of fuel wood as a primary source of energy.

Oil is always pumped together with water and they must be separated. There are big volumes of produced water stagnant in ponds with apparently inadequate treatment such as skimming which is less effective[48]. The discharge of produced water causes serious environmental risks to both human and the natural environment and the use of technologies such as high efficient halophile oil-degrading microorganisms in biological treatment should be combine with membranes (SBR) biological treatment systems for effective management of produced water since the Dar blend crude oil is acidic in nature and contain heavy metals[20], The pipelines are causing major problems from leaking leading to massive oil spills along the transportation line to the sea terminal at port Sudan requires proper maintenance and monitoring.

V. Conclusion

Oil exploration and production have had serious implication on the environment, oil spill and gas flaring have contaminated, degraded and destroyed the forests, and water bodies of the Melut basin, thereby causing serious destruction of its biodiversity over the years.

The harmful effects of oil exploration and exploitation on the environment are many. Oil spill kills plants and animals in both the plain and the estuarine. Oil settles on green plants hence preventing the photosynthesis process leading to reduction of its ability to sustain life especially in the agro-pastoralist community as it is in the case of Melut basin. oil endangers fish hatcheries in the swamps and also contaminates the flesh of commercially valuable fish since Sudd wetlands and Machar wetlands is a home to millions of fish stock that forms the primary diet of the community surrounding the oil enclaves. Soils and river sediments, in the vicinity or downstream, respectively from oil extraction and processing infrastructure in the savannah grassland of Paloich area of the greater Upper Nile region contain an oil pollution signature. This is not an unexpected finding in a worldwide context given that the oil industry infrastructure commonly has a significant environmental impact in the surrounding lands, be it during exploration, extraction, processing, transport and distribution processes.

The hydrocarbons in sediments in the water courses could have eventually reached the main watercourse of the Nile as already noted for other chemical components present in produced waters and surface water around the oil fields[25, 30]. Spillages in soils are likely to have a local impact.

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AUTHORS

First Author – LORO Emmanuel Ladu Legge

Master's Degree Candidate, UN Environment – Tongji Institute of Environment and Sustainable Development, College of Environmental Science and Engineering, Tongji University, Shanghai, P, R China
Phone: +86 131 208 12530
E-mail: laduloro@gmail.com
Second Author – **Prof. Lu Zhibo**
Supervisor and Co-author
College of Environmental Science and Engineering
Tongji University, Shanghai, P.R China
Phone: +86 136 6169 2065
E-mail: zhibolu@126.com

Correspondence Author – **LORO Emmanuel Ladu Legge**
Master's Degree Candidate, UN Environment – Tongji Institute of Environment and Sustainable Development, College of Environmental Science and Engineering, Tongji University, Shanghai, P, R China
Phone: +86 131 208 12530
E-mail: laduloro@gmail.com, or 1793403@tongji.edu.cn