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Oil and Gas Pipeline Construction-Induced Forest Fragmentation and Biodiversity Loss in the Niger Delta, Nigeria

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Abstract

The impacts of oil and gas pipeline construction on the forest and biodiversity in parts of the Niger Delta was investigated. This was achieved by studying the construction activities and operational phases of two pipelines with cumulative length of 165 km vis-à-vis the biodiversity of the affected area. The study involved field sampling along the RoWs to inventorize the fauna and flora, visual assessments and interview with locals. It was observed that the pipelines traversed moist low-land/freshwater swamp and mangrove forests, and barrier islands with approximately 4,950,000 m² (equivalent of 495 hectares) of forest cleared and 9,642,000 trees killed to realize the pipelines. A total of 219 plant species in 66 families and 125 different fauna species from 64 families were recorded in these areas. Three out of the 4 recorded species of Meliaceae were threatened based on IUCN Conservation Status. Also based on IUCN Conservation Status, 20 mammals, including *Pan troglodytes*, *Cercopithecus erythrogaster* and *Trichechus senegalensis*, 7 birds, 2 reptiles and 1 amphibian were within threatened group. The results showed that the study area had witnessed colossal loss of biodiversity due to habitat displacement, forest fragmentation and deforestation, and escalated exploitation of species. The study identified the most affected biodiversity, and proffered measures to mitigate such occurrences.

Keywords

Biodiversity, Forest Fragmentation, Pipeline Construction, Right of Way, Niger Delta

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1. Introduction

The Niger Delta covers an area of approximately 50,000 km^2 between Latitudes 4˚0'0"N and 8˚0'0"N, and Longitudes 5˚0'0"E and 7˚0'0"E [1] (**Figure 1**). It is within two meters above sea level [2] and extends over four ecological zones: coastal barrier islands, brackish/saline water mangrove swamps, freshwater swamp forests (permanent and seasonal), and dry upper plain lowland rain forests [3]. The hydrological boundaries between these ecological zones are imperceptible; so also are some of the forest zones particularly the fringing of the mangrove forest and freshwater swamp forest. It is also the largest wetland in Africa with rich biological diversity [1] [4]-[8]. Its mangrove forest is the largest in Africa (11,134 km^2) and the fourth largest in the world [9].

Across the different ecological zones, the Niger Delta is home to diverse assemblages of Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) wildlife species. Some of the threatened species, which have been previously reported in IUCN red list are the pygmy hippopotamus (*Choeropsis liberiensis*), manatees (*Trichechus senegalensis*), maritime hippopotamus (*Hippopotamus amphibious*), Nile crocodile (*Crocodylus niloticus*), slender nosed crocodile (*Crocodylus cataphractus*) and dwarf crocodile (*Osteolaemus tetraspis*) [3] [4]. Ohimain [5] also reported that such wildlife species as the Cape clawless otter (*Aonyx capensis*), African palm nut vulture (*Gypohierax angolensis*), fire-footed squirrel (*Funisciurus pyrropus*), Hammerkop (*Scopus umbretta*), African fish eagle (*Haliaeetus vocifer*), Sclater's guenon (*Cercopithecus sclateri*), sitatunga (*Tragelaphus spekei*), white throated monkey (*Cercopithecus erythrogaster*), which occurred in the area required conservation.

However, the Niger Delta is known and recognized globally not for the rich biological diversity but for its non-renewable oil and gas resources. The region is home to the hydrocarbon exploration and production activities in Nigeria where proceeds from this singular industry (*i.e.*, oil and gas) accounts for over 90% of the nation's total export earnings [1]. With proven crude oil reserve of 37.2 billion barrels, 165 trillion standard cubic feet (scf) of natural gas, 75.4 trillion scf of non associated gas and average of 2.28 million barrels of crude oil production per day, Nigeria is Africa's largest crude oil producer, the world's 11th largest producer as well as 8th largest exporter 2011 [10]. Nigeria has been exporting crude oil from this region since 1958. Effective oil and gas exploration and production has therefore taken place in this region described as environmentally sensitive

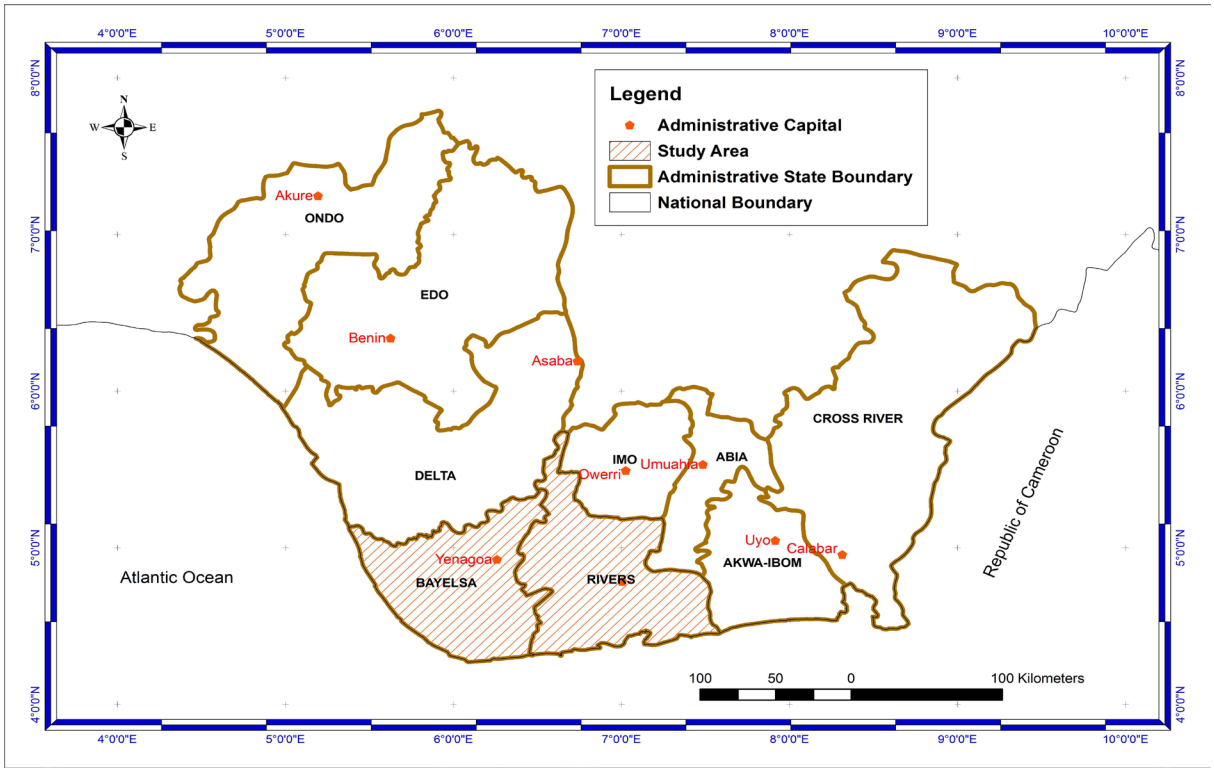

Figure 1. Map showing the Niger Delta of Nigeria.

and fragile [1] [3], with brackish and fresh water swamps cris-crossed by anastomosing network of rivers, creeks and distributaries/tidal channels [7] for more than fifty years. This will likely continue for the next fifty years or more.

The completion of every successful oil and gas exploration and production activity is to hook up the producing well to a gathering facility through a flowline. The gathering facility may be a flow station or Floating Production Storage and Offloading (FPSO) system (strictly offshore). These products are transported from the gathering facility to a refinery or outright selling point (terminals) through pipelines. In the Niger Delta the flowlines and pipelines range from diameter of six inches (6") to thirty six inches (36") with Right of Way (RoW) of 15 m to 30 m in width. Their construction involves acquisition and clearing the RoW of all vegetation and wildlife, and excavation by the open-cut method (thrust boring at major road and river crossings). The open cut method requires deployment of excavators and other earth-moving equipment: the depth of excavation ranging from 3 m to 15 m. Backfilling after pipe laying is mostly haphazard resulting in blockage of natural drainages and eventual flooding [6] [7]. At present, there are 23 export terminals, 112 flow stations and over 20,000 km of flowline/pipeline infrastructure concentrated within this 50,000 km^2 area.

Studies and reports implicating different oil and gas exploration and production activities in the Niger Delta to forest fragmentation and overall biodiversity depletion abound [1] [3]-[7] [11]-[18]. Empirical investigations into flowline/pipeline construction activities and their operation vis-à-vis their impacts on this ecologically and biologically diverse but fragile and sensitive region are lacking. This study investigates and quantifies the impact of flowline/pipeline construction activities in the Niger Delta and proffers remedial measures to mitigate and restore adversely impacted areas.

2. Materials and Methods

2.1. Study Area and Rationale

The field studies were conducted between 2009 and 2012 in Rivers and Bayelsa States within latitudes 4˚0'0"N and 6˚0'0"N, and longitudes 5˚0'0"E and 7˚0'0"E (**Figure 1**). The studies were tailored to capture two broad categories of oil and gas pipeline impacts on biodiversity (*i.e.*, plants and wildlife) viz: (i) impacts associated with pipeline construction and (ii) impacts associated with the operational phase of pipeline facilities. To achieve these objectives, two different pipeline RoWs at different stages of existence were chosen.

1) A 45 km pipeline project under construction (**Figure 2(A)**). This is within lowland and freshwater swamp forests. RoW clearing and excavation/trenching activities were observed vis-à-vis impacts on biodiversity.

2) A 120 km long pipeline (**Figures 2(B)-(D)**), which has been in existence for upwards of twenty five (25) years. The pipeline originated in a lowland rainforest, crossed seasonal and permanent freshwater swamp forests, mangrove forests and terminated in a barrier island. During the study, a section of this pipeline within the mangrove forest section was being replaced. This replacement activity increased the opportunity to document construction impact on the mangrove forest area.

Study methodology included inventory/sampling of plant and animal species, observations and use of still life photographs and interview/discussions with locals; comparison with forest climaxes in contiguous areas and by copious reference to existing information [9]. For vegetation and wildlife assessments, the pipeline RoWs provided continuous linear transect.

2.2. Vegetation Sampling and Assessment

At each sampling point along the transect, a tape measure was used to mark out 100 m × 100 m plot. Each 100 m × 100 m plot was further demarcated into four random blocks of 20 m × 20 m. This was to ease sampling and increase the opportunity of encountering all plant species during inventory. Within each chosen block, vegetation assessment was made through copious visual observations of the status of the flora. On-site identification as well as inventory of all plant species within each sample station was carried out. Data obtained was further used for determining the density, relative distribution and frequency of occurrence of major plant species. The structure and physiognomy of the vegetation of the area [height, crown diameter and crown depth of all woody stems 3 m or more in height or over 10cm in diameter at breast height (1.3 m)] were estimated in the field and ratified with reference to Richards [19]. Trees were identified to species level using Flora of Tropical West Africa [20]-[22] and Trees of Nigeria [23].

Figure 2. (A) Section of the 45 km pipeline under construction in moist lowland rainforest section. Notice the different earth moving equipment, excavated earth, pipes; (B)-(D) Different segments of the 120 km existing pipeline RoW ((B) is along lowland rainforest area, (C) is across freshwater swamp forest area, and (D) is through mangrove swamp forest *i.e.*, brackish water area).

2.3. Wildlife Survey and Assessment

The wildlife assessment involved a survey of amphibians, reptiles, birds, and mammals in the study areas using the existing RoW as linear transects. For the census of the birds, reptiles and other animals, which readily offered themselves for observation, the direct count method was adopted using a pair of binoculars. By probing such humid habitats as logs, heaps of dry or decaying leaves, ponds, forest undergrowth and burrows, the presence of some animals like amphibians, reptiles and small mammals were revealed. All captured, dislodged or sighted animals were identified, often on the spot, to possible taxonomic levels using field guides and keys [24]-[28]. For species which do not offer themselves readily for observation, the indirect method, which makes use of evidence of animal's presence [29], was used. Such signs of animal occupation as burrows, faecal pellets (droppings), hairs, foot prints or tracks, sloughed skin, devoured food (cassava, yam tubers, oil-palm fruits, other fruits), as well as vocalization, skeleton/carcass and trampled grass were of immense use in the course of the investigation. Further information on the wildlife diversity, abundance and use in the areas were obtained through inspecting series of traps and snares set by hunters and interviewing them. Wildlife species displayed for sale around villages close to the RoWs were noted.

3. Results

3.1. Status of the Forest and Vegetation of the Area

The 165 km study area comprises 133 km of moist lowland/freshwater swamp and 32 km of mangrove swamp forests. Typically, the pipeline RoWs have width of 30 m. Thus, approximately 4,950,000 m^2 (equivalent of 495 hectares) area of moist lowland/freshwater swamp forest (3,990,000 $m^2 \approx 399$ hectares from 133 km long RoW)

and mangrove swamp forest (960,000 $m^2 \approx 96$ hectares for 32 km) was cleared to realize the pipelines. Observations and results from the study show that the area has different forest ecosystems, which are rich in biological diversity. A total of 219 species (192 in moist lowland rainforest, 113 in freshwater swamp forest and 8 in mangrove swamp forest) of plants from 66 different families were recorded (**Table 1**). The family Leguminosae

Table 1. List of plant species showing their distribution/occurrence in the different forest types.

S/N	Plant Species	Common Name	Family	*Lowland	**Freshwater	Mangrove	Habit and Status
1	*Acanthus montanus* (Nees) T. Anders	False thistle	Acanthaceae	+	+	−	Herb
2	*Nelsonia canescens* (Lam) Spreng	NA	Acanthaceae	+	+	−	Herb
3	*Adiantum vogelli* Mett ex Keys	Fern	Adiantaceae	+	−	−	Herb
4	*Acrostichum aureum.* L.	Salt water fern	Adiantaceae	−	−	+	Herbaceous perennial
5	*Pteris acamthoneura* Alston	Fern	Adiantaceae	+	−	−	Herb
6	*Alternanthera* sessilis (L.) DC. R. Br. *ex.* Roth	Sessile joy weed	Amaranthaceae	+	−	−	Herb
7	*Amaranthus spinosus* L.	Spiny amaranth	Amaranthacae	+	−	−	Herb
8	*Pupalia lappacea* (L) Juss	NA	Amaranthaceae	+	−	−	Herb
9	*Crinum jagus* (Thomps) Dandy	Bush onion	Amarillidaceae	+	+	−	Herb
10	*Spondias mombin* L.	Africa hug plum	Anacardiaceae	+	−	−	Tree
11	*Spondias dulcis* L.	Hug plum	Anacardiaceae	+	+	−	Tree (Not evaluated)
12	*Mangifera indica* L.	Mango	Anacardiaceae	+	−	−	Tree (Fruit)
13	*Cleistopholis patens* (Benth.) Engl. & Diels	Salt and oil	Annonaceae	−	+	−	Tree (Not Evaluated)
14	*Xylopia aethiopia* (Dunal) A. Rich	Guinea pepper	Annonaceae	+	+	−	Tree (Not evaluated)
15	*Voacanga africana* Stapf.	NA	Apocynaceae	+	−	−	Tree (Not evaluated)
16	*Alstonia boonei* De Wild.	Alstonia/pattern wood	Apocynaceae	+	+	−	Tree (Not evaluated)
17	*Tabernaemontana pachysiphon* Stapf	NA	Apocynaceae	+	+	−	Small tree – not evaluated
18	*Funtumia africana* (Benth) Stapf.	False rubber tree	Apocynaceae	+	+	−	Tree
19	*Funtumia elastic* (Preuss) Stapf	Silkrubber	Apocynaceae	+	+	−	Tree
20	*Landolphia owaniensis* P. Beauv	White rubber vine	Apocynaceae	+	−	−	Climber/Liana (Fruit)
21	*Landolphia dulcis* (R. Br) Pichon	NA	Apocynaceae	+	−	−	Climber/Liana (Fruit)
22	*Rauvolfia vomitoria* Afzel	Swizzle stick	Apocynaceae	+	−	−	Small tree
23	*Culcasia scandens* P. Beauv	Common climbing arum	Araceae	+	+	−	Herb (Least concern)
24	*Anchomanes difformis* (Blume) Engl.	NA	Araceae	+	+	−	Herb
25	*Xanthosoma mafaffa* Schott	Cocoyam	Araceae	+	−	−	Herb (Tuber)
26	*Cyrtosperma senegalense* (Schott) Engl.	Swamp aureum	Araceae	−	+	−	Herb (Least concern)

27	*Cocos nucifera* Linn	Coconut	Arecaceae	+	+	−	Tree (Fruit)
28	*Ancistrophyllum secundiflorum* (P. Beauv) Wendl.	Climbing palm	Arecaceae	+	+	−	Climber/Liana
29	*Raphia hookeri* G. Mann & H. Wendl.	Raffia palm	Arecaceae	−	+	−	Tree
30	*Elaeis guineensis* Jacq	Oil palm	Arecaceae	+	+	−	Tree
31	*Laccosperma arcutiflora* (Becc.) J. Dransf	NA	Arecaceae	+	+	−	Shrub
32	*Laccosperma opacum* (G. Mann & H.Wendl) Drude	Oga plant	Arecaceae	+	+	−	Shrub
33	*Borassus aethiopum* Mart	African fan palm	Arecaceae	+	−	−	Tree
34	*Nypa fruticans* Wumb.	Nypa palm	Arecaceae	−	−	+	Shrub (Least concern)
35	*Daemia extensa* (Forssk) Chev	NA	Asclepiadaceae	+	−	−	Climber
36	*Chromolaena odorata* (Linn) King & Robinson	Siamweed	Asteraceae	+	−	−	Shrub
37	*Conyza sumatrensis* (Retz) E.H. Walker	NA	Asteraceae	+	−	−	Herb
38	*Synedrella nodiflora* (L.) Gaertn	Nodeweed	Asteraceae	+	−	−	Herb
39	*Aspilia africana* (Pers) C.D. Adams	Haemorhage plant	Asteraceae	+	−	−	Herb
40	*Mikania cordata* (Burm F.) Robinson	Climbing hemp weed	Asteraceae	+	+	−	Climber
41	*Vernonia amygdalina* Del	Bitter leaf	Asteraceae	+	−	−	Shrub
42	*Ageratum conyzoides* L.	Goat weed	Asteraceae	+	−	−	Herb
43	*Diplazium sammatii* (Kuhn) C. Chr.	NA	Athyraceae	−	+	−	Herb
44	*Avicenia africana* P. Beauv.	White mangrove	Avicenaceae	−	−	+	Tree (Not evaluated)
45	*Kigelia africana* (Lam.) Beneth.	Sausage plant	Bignoniaceae	+	+	−	Tree (Not evaluated)
46	*Newbouldia laevis* Seem	African Border tree	Bignoniaceae	+	−	−	Tree
47	*Ceiba pentandra* (L.) Gaertn	Cotton wood tree	Bombacaceae	+	+	−	Tree (Not evaluated)
48	*Bombax buonopozense* P. Beauv.	Silt cotton tree	Bombacaceae	+	+	−	Tree (VU)
49	*Heliotropum indicum* L.	Cock's comb	Boraginaceae	+	+	−	Herb
50	*Canarium schweinfurthii* Engl.	NA	Burseraceae	+	+	−	Tree
51	*Dacryodes edulis* (G. Don) H.J. Lam	Native pear	Burseraceae	+	−	−	Tree
52	*Carica papaya* L.	Pawpaw	Caricaceae	+	−	−	Tree
53	*Musanga cecropoides* R. Br.	Umbrella tree	Cecropiaceae	+	+	−	Tree
54	*Chrysobalanus orbicularis* Schumach.	NA	Chrysobalanaceae	+	−	−	Shrub
55	*Combetum zenkeri* Engl. & Diels	NA	Combretaceae	+	−	−	Climber
56	*Terminalia catappa* L.	Almond Indian fruit	Combretaceae	+	−	−	Tree
57	*Terminalia iverensis* A. Chev	Black afara	Combretaceae	+	+	−	Tree (VU)

Continued

58	*Terminalia superba* Engl. & Diels	Terminalia or Afara	Combretaceae	+	+	−	Tree
59	*Laguncularia racemosa* (L.) C.F. Gaertn.	White mangrove	Combretaceae	−	−	+	Shrub (Least concern)
60	*Commelina erecta* L.	White mouth dew flower	Commelinaceae	+	−	−	Herb
61	*Commelina benghalensis* L.	Wandering Jew	Commelinaceae	+	−	−	Herb
62	*Ipomoea aquatica* Forssk	Ipomoea	Convulvulaceae	+	+	−	Trailing herb
63	*Lepistemon owariense* (P. Beauv) Hallier F.	NA	Convulvulaceae	+	−	−	Twining perennial
64	*Ipomoea involucrata* P. Beauv	NA	Convulvulaceae	+	−	−	Trailing herb
65	*Ipomoea batatas* (L.) Lam	Sweet potato	Convulvulaceae	+	−	−	Trailing herb
66	*Costus lucanusianus* J. Braun and K. Schum.	Bush cane	Costaceae	+	−	−	Shrub
67	*Costus spectabilis* Schum (Fenzl) K.	Dwarf ginger lili	Costaceae	+	−	−	Herb
68	*Costus afer* K. Gawl	Bush cane	Costaceae	+	−	−	Shrub
69	*Lagenaria guineensis* (G. Don) C. Jeffrey	Cucurbit	Cucurbitaceae	+	+	−	Climbing Herb
70	*Zehnaria cinerea*	NA	Cucurbitaceae	+	+	−	Climbing Herb
71	*Luffa aegyptiaca* Mill.	Sponge gourd	Cucurbitaceae	+	−	−	Climbing Herb
72	*Momordica charantia* L.	Bitter gourd	Cucurbitaceae	+	−	−	Climbing Herb
73	*Coccinia barteriI* (Hook. f) Keay	NA	Cucurbitaceae	+	−	−	Climbing Herb
74	*Scleria verrucosa* Wild	Bush knife	Cyperaceae	+	−	−	Herb
75	*Scleria naumanniana* Boeck	Bush knife	Cyperaceae	+	−	−	Herb
76	*Bulbostylis* sp	Sedge	Cyperaceae	+	−	−	Herb
77	*Kyllinga erecta* Schumach	Sedge	Cyperaceae	+	−	−	Herb
78	*Mariscus longibracteatus* Cherm	Sedge	Cyperaceae	−	+	−	Herb
79	*Mariscus flabelliformis* Kunth	Sedge	Cyperaceae	+	−	−	Herb
80	*Kyllinga pumila* Michx	Sedge	Cyperaceae	+	−	−	Herb
81	*Tetracera affinis* Hutch	NA	Dilleniaceae	+	+	−	Scrambling shrub
82	*Dioscorea smilacifolia* De Wild	Bush yam	Dioscoreaceae	+	+	−	Climber
83	*Dioscorea sansibarensis* Pax	Bush yam	Dioscoreaceae	+	−	−	Climber
84	*Dracaena mannii* Barker	Small-leaved dragon tree	Dracaenaceae	+	+	−	Tree
85	*Dracaena arborea* (Willd.) Link	African dragon tree	Dracaenaceae	+	−	−	Tree
86	*Diospyros crassiflora* Hiern	Ebony	Ebenaceae	+	+	−	Tree (Threatened)
87	*Phyllanthus amarus Schum* & Thonn	Stone breaker	Euphorbiaceae	+	+	−	Herb
88	*Ricinodendron heudelotii* (Bill.) Pierre	Corkwood tree	Euphorbiaceae	+	+	−	Tree (VU)
89	*Alchornea laxiflora* (Benth) Pax & K. Hoffin	Christmas bush	Euphorbiaceae	+	+	−	Shrub

Continued

90	*Manniophyton fulvum* Mull-Arg	NA	Euphorbiaceae	+	−	−	Shrub
91	*Bridella ferruginea* Benth	NA	Euphorbiaceae	+	+	−	Tree
92	*Alchornea cordifolia* (Schum & Thonn) Mull.-Arg.	Christmas bush	Euphorbiaceae	+	+	−	Shrub
93	*Manihot esculenta* Crantz	Cassava	Euphorbiaceae	+	−	−	Shrub
94	*Euphorbia hirta* Linn	Asthma herb.	Euphorbiaceae	+	−	−	Herb
95	*Jatropha curcas* Linn	Purge nut	Euphorbiaceae	+	−	−	Shrub
96	*Antidesma vogelianum* Mull-Arg	NA	Euphorbiaceae	+	+	−	Tree
97	*Uapaca heudelotii* Baill.	Uapaca	Euphorbiaceae	−	+	−	Tree
98	*Milletia arboensis* (Hook F.) Bak	NA	Leguminosae	+	+	−	Tree
99	*Berlinia gradiflora* (Vahl) Hutch & Dalz	NA	Leguminosae	+	−	−	Tree
100	*Dialium guineense* Wild	Velvet tamarind	Leguminosae	+	−	−	Tree
101	*Desmodium scorpiurus* (Sw) Desv	NA	Leguminosae	+	+	−	Herb
102	*Desmodium ramosissimum* G. Don	NA	Leguminosae	+	+	−	Semi-woody Herb
103	*Anthonotha macrophylla* P. Beauv	NA	Leguminosae	+	+	−	Tree
104	*Anthonotha obanensis* (Bak T.) Leonard	NA	Leguminosae	+	+	−	Tree
105	*Baphia nitida* Lodd	Camwood	Leguminosae	+	+	−	Shrub
106	*Lonchocarpus sericeus* (poir) H.B & K.	Cube root	Leguminosae	−	+	−	Small Tree
107	*Brachystegia eurycoma* Harms	NA	Leguminosae	+	+	−	Tree
108	*Mimosa inuisa* Mart ex. Colla	Sensitive plant	Leguminosae	+	+	−	Shrub
109	*Tetrapleura tetraptera* (Schum & Thonn. Taub)	NA	Leguminosae	+	+	−	Tree
110	*Amphimas pterocarpoides* Hams.	Bokanga	Leguminosae	+	+	−	Tree (Not evaluated)
111	*Dalbergia ecastaphyllum* (L.) Taub.	Coin vine	Leguminosae	−	−	+	Shrub (Not evaluated)
112	*Albizia adiantifolia* (Schum) W. Wight	West African albizia	Leguminosae	+	+	−	Tree
113	*Mimosa pudica* Linn	Sensitive plant	Leguminosae	+	−	−	Herb
114	*Pentaclethra macrophylla* Benth	Oil bean	Leguminosae	+	+	−	Tree
115	*Piptadeniastrum africanum* (Hook.f.) Brenam	False sasswood or African greenheart	Leguminosae	+	+	−	Tree (Not evaluated)
116	*Pueraria phaseoloides* (Roxb) Benth	Tropical kudzu	Leguminosae	+	−	−	Climber
117	*Pterocarpus milbraedii* Harms	NA	Leguminosae	+	−	−	Tree
118	*Pterocarpus santalinoides* DC	NA	Leguminosae	+	−	−	Tree (Least concern)
119	*Mucuna sloanei* Fawc. & Rendle	Hamburger bean	Leguminosae	+	−	−	Climber

Continued

120	*Calopogonium mucunoides* Desv		Leguminosae	+	−	−	Climbing Herb
121	*Acacia kamerunensis* Gandoger	NA	Leguminosae	+	−	−	Shrub
122	*Harungana madagascarensis* Poir ex. Lam	Dragon's blood	Guttiferae	+	+	−	Tree
123	*Symphonia globulifera* L.f.	Hog gum tree	Guttiferae	−	+	−	Tree (Data deficient)
124	*Pentadesma butyracea* Sabine	Tallow tree	Guttiferae	+	+	−	Tree (Not evaluated)
125	*Icacina triacantha* Oliv	NA	Icacinaceae	+	−	−	Herb
126	*Irvingia gobonensis* (Aubry-Lecomte ex O'Rorke) Baill	Bush mango or dikanut	Irvingiaceae	+	+	−	Tree (Near threatened)
127	*Klainedoxa gabonensis* Pierre	Timber wood	Irvingiaceae	+	+	−	Tree (Not evaluated)
128	*Persea gratissima* Mill	Avocado pear	Lauraceae	+	−	−	Tree (fruit)
129	*Anthocleista nobilis* G. Don	Cabbage tree	Logoniaceae	+	−	−	Tree
130	*Spigelia anthelmia* Linn	worm grain	Loganiaceae	+	−	−	Herb
131	*Abelmoschus esculentus* (Linn) Moench	Okro	Malvaceae	+	−	−	Shrub
132	*Sida acuta* Burm.f.	NA	Malvaceae	+	−	−	Herb
133	*Urena lobata* L.		Malvaceae	+	−	−	Shrub
134	*Marrattia fraxinea* Sm	Pteridophyte	Marattiaceae	+	−	−	Herb
135	*Marantochtoa leucantha* (K. Schum) Milne-Redh	Yoruba soft cane	Marantaceae	+	+	−	Herb
136	*Memecylon blakeoides* G. Don	NA	Melastomataceae	−	+	−	Tree
137	*Osbeckia tubulosa* Smith	NA	Melastomataceae	−	+	−	Herb
138	*Khaya ivorensis* A. Chev	Mahogany	Meliaceae	+	+	−	Tree (Threatened)
139	*Entandrophragna cylindrium* Hams	Sapele mahogany	Meliaceae	+	+	−	Tree (VU)
140	*Guarea cedrata* (A. Chev.) Pellegrin	Pink African cedar	Meliaceae	+	+	−	Tree (VU)
141	*Carapa procera* DC	Monkey cola or Crab wood	Meliaceae	+	+	−	Tree
142	*Ficus sur* Forssk	Bush fig	Moraceae	+	+	−	Tree
143	*Ficus mucoso* Welw ex. Falcalh	Fig tree	Moraceae	+	−	−	Tree
144	*Ficus exasperata* Vahl.	Sand paper	Moraceae	+	−	−	Shrub
145	*Milicia excelsa* (Welw) C.C. Berg	Iroko tree	Moraceae	+	+	−	Tree (Threatened)
146	*Artocarpus altilis* (Park) Fosberg	Bread fruit	Moraceae	+	+	−	Tree
147	*Morus mesozygia* Stapf.	NA	Moraceae	+	+	−	Tree
148	*Treculia africana* Decne	African bread fruit	Moraceae	+	+	−	Tree
149	*Musa sapientum* L.	Banana	Musaceae	+	−	−	Tree
150	*Musa paradisiaca* L.	Plantain	Musaceae	+	−	−	Tree
151	*Myristica fragrans*	Nutmeg	Myristicaceae	+	+	−	Tree

Continued

152	*Pycnanthus angolense* (Welw.) Warb.	Wild nutmeg	Myristicaceae	+	+	−	Tree
153	*Psidium guajava* L.	Guava	Myrtaceae	+	−	−	Fruit Tree
154	*Eugenia owariensis* L.	African rose apple	Myrtaceae	−	+	−	Tree
155	*Syzygium guineense* (Willd.) DC.	Water berry	Myrtaceae	−	+	−	Tree
156	*Lophira alata* Banks ex Gaertn.	Red ironwood	Ochnaceae	+	+	−	Tree (VU)
157	*Ludwigia abyssinica* A. Richard	NA	Onagraceae	+	+	−	Herb
158	*Ludwigia decurrens* Walter	Willow primrose	Onagraceae	+	+	−	Herb
159	*Bulbophyllum barbigerum* Lindl	Epiphyte orchid	Orchidaceae	+	+	−	Herb
160	*Microdesmis puberula* Hook F.	NA	Pandaceae	+	−	−	Shrub
161	*Pandanus candelabrum* P. Beauv.	NA	Pandanaceae	−	+	−	Shrub
162	*Adenia lobata* (Jacq) Engl.	NA	Passifloraceae	+	−	−	Herb
163	*Chloris pilosa* Schumach	Finger grass	Poaceae	+	+	−	Herb
164	*Pennisetum purpureum* Schumach	Elephant grass	Poaceae	+	−	−	Herb
165	*Eleusine indica* (L) Gaertn	Wire grass	Poaceae	+	−	−	Herb
166	*Digitaria horizontallis*	Grass	Poaceae	+	+	−	Herb
167	*Axonopus compressus* (SW.) P. Beauv	Carpet grass	Poaceae	+	−	−	Herb
168	*Panicum laxum* SW	Grass	Poaceae	+	+	−	Herb
169	*Panicum maximum* Jacq	Guinea grass	Poaceae	+	−	−	Herb
170	*Bambusa vulgaris* Schrad	Indian bamboo	Poaceae	+	+	−	Tree
171	*Andropogon tectorum* Schum & Thonn.	Giant blue stem	Poaceae	+	−	−	Herb
172	*Sporobolus paniculatus* (Trin) (Trin) Dur. & Schinz Dur	Grass	Poaceae	+	−	−	Herb
173	*Sporobolus pyramidalis* P. Beauv	Rats tail grass	Poaceae	+	−	−	Herb
174	*Chrysopogon aciculatus* (Retz) Trin	Love grass	Poaceae	+	−	−	Herb
175	*Eragrostis tenella* (*Linn*) P. Beauv	Ross grass	Poaceae	+	−	−	Herb
176	*Sorghum arundinaceum* (Desv) Stapf	Kamerun grass	Poaceae	−	+	−	Shrub
177	*Acroceras zizanoides* (Kunth) Dandy	Grass	Poaceae	+	+	−	Herb
178	*Saccharum officinarum* Linn	Sugar cane	Poaceae	−	+	−	Shrub
179	*Polygonium pulchrum* Blume	NA	Polygonaceae	−	+	−	Herb
180	*Eichhornia crassipes* (Mart.) Solms.	Water hyacinth	Pontederiaceae	−	+	−	Floating herb
181	*Talinum triangulare* (Jacq) Wild	Waterleaf	Portulacaceae	+	−	−	Herb (vegetable)
182	*Portulaca oleracea* L.	Common purslane	Portulacaceae	+	−	−	Herb (vegetable)
183	*Rhizophora racemosa* G.R.W Meyer	Red mangrove	Rhizophoraceae	−	−	+	Tree
184	*Rhizophora mangle* L.	Mangrove	Rhizophoraceae	−	−	+	Tree

Continued

185	*Rhizophora harrisonii* Leechm	Mangrove	Rhizophoraceae	−	−	+	Tree
186	*Hallea ciliata* Aubr & Pellegr	Abura	Rubiaceae	+	+	−	Tree
187	*Oldenlandia corymbosa* L.	Flat top mille grained	Rubiaceae	−	+	−	Herb
188	*Ixora coccinea* L.	Jungle flame Ixora	Rubiaceae	+	−	−	Shrub (ornamental)
189	*Sabicea calycina* Benth	NA	Rubiaceae	+	+	−	Shrub
190	*Mussaenda landolphioides* Wernham	NA	Rubiaceae	−	+	−	Woody climber
191	*Mitracarpus scaber* Zucc.	NA	Rubiaceae	+	−	−	Herb
192	*Nauclea latifolia* Sm.	NA	Rubiaceae	+	−	−	Tree
193	*Morinda lucida* L.	Brimstone tree	Rubiaceae	+	+	−	Tree
194	*Psychotria vogeliana* Benth.	Wood cork	Rubiaceae	+	+	−	Shrub
195	*Rothmannia whitfieldii* (Lindl.) Dandy	NA	Rubiaceae	+	+	−	Shrub
196	*Citrus sineensis* (L.) Osbeck	Sweet orange	Rutaceae	+	−	−	Tree
197	*Paullinia pinnata* L.	Bread and cheese	Sapindaceae	+	+	−	Tree
198	*Scoparia dulcis* L.	Sweet broom weed	Scrophulariaceae	+	−	−	Herb
199	*Selaginella myosurus* (Sw.) Alston	Fern	Selaginellaceae	+	+	−	Herb
200	*Similax anceps* Wild.	West African sarsaparilla	Smilacaceae	+	+	−	Climber
201	*Physalis angulata* L.	Angular winter cherry	Solanaceae	+	−	−	Herb
202	*Capsicum frutescens* L.	Red pepper	Solanaceae	+	−	−	Herb
203	*Solanum melongena* L.	Garden egg	Solanaceae	+	−	−	Herb
204	*Solanum torvum* Sw.	Turkey berry	Solanaceae	+	−	−	Shrub
205	*Capsicum annum* L.	Sweet red guinea pepper	Solonaceae	+	−	−	Herb
206	*Triplochiton scleroxylon* K. Schum	Obeche	Sterculiaceae	+	+	−	Tree (Threatened)
207	*Sterculia tragacantha* Lindl	African tragacanth	Sterculiaceae	+	+	−	Tree
208	*Chrysophyllum albidum* G.Don	Star apple	Sterculiaceae	+	−	−	Tree
209	*Cola gigantea* A. Chev.	Giant cola	Sterculiaceae	+	+	−	Tree (Threatened)
210	*Cola laurifolia* Mast.	NA	Sterculiaceae	+	+	−	Tree (Threatened)
211	*Cola hispida* Brenan & Keay	NA	Sterculiaceae	+	−	−	Shrub
212	*Truimfetta esiophlebia* Hook F.	African jute plant	Tiliaceae	+	+	−	Shrub
213	*Truimfetta cordifolia* A. Rich	Bur weed	Tiliaceae	+	+	−	Shrub
214	*Glyphaea brevis* (Spreng.) Monach	NA	Tiliaceae	+	+	−	Tree
215	*Clappertonia ficifolia* (Willd.) Decne	Clappertonia	Tiliaceae	−	+	−	Shrub
216	*Duranta repens* Linn	Golden dewberry	Verbenaceae	+	−	−	Shrub
217	*Gmelina arborea* Roxb	Gmelina	Verbenaceae	+	−	−	Tree
218	*Vitex grandifolia* Gurke	Black plum	Verbenaceae	+	+	−	Tree
219	*Aframonum melagueta* K. Schum.	Guinea pepper	Zingiberaceae	+	+	−	Herb (Not evaluated)
	Total number of species in each forest			192	113	8	

*__Lowland__ = Moist Lowland Rainforest; **__Freshwater__ = both seasonal and permanent freshwater swamp forest; NA = not applicable *i.e.*, no common name; + = present; − = not present.

(Fabaceae) was represented by 24 species (10.96%), Poaceae by 16 species (7.31%), Euphorbiaceae by 11 species (5%), Rubiaceae by 10 species (4.57%), Apocynaceae and Arecaceae by 8 species (3.65% each) **Figure 3(A)**. While Asteraceae, Cyperaceae and Moraceae contributed seven species each, Combretaceae, Cucurbitaceae and Solanaceae each contributed five species of the identified 219 species. The family Sterculiaceae was represented by six species, while 3 out of the 4 recorded species of Meliaceae, which are commercial timber species, are threatened based on IUCN [30] Conservation Status. The remaining 25 families were represented by a species each (**Table 1**). The percentage contributions of the different families based on the habit of the plants is as follows: herbs 70 species (31.96%), trees 92 species (42%), climbers/liana 21 species (9.59%) and shrub 36 species (16.44%) as shown in **Figure 3(B)**. The forest inventory revealed average of 22 stands of trees in each $10m^2$ area of the lowland rainforest/freshwater swamp forest and average of 9 stands of mangrove trees in $10m^2$ mangrove swamp forest. Based on this information, it is estimated that 8,778,000 stands of lowland rainforest/freshwater swamp forest trees and 864,000 stands of mangroves were destroyed in the process of actualizing the construction of the pipelines.

3.2. Status of the Wildlife of the Area

Wildlife inventory (invertebrates not included) in the area revealed considerable diversity of wildlife species in 4 broad groups. This comprised 125 different fauna species from 64 families (**Table 2-5**). Mammals from 22 families (**Table 2**) accounted for 44 (35.2% of total number of species) of the species described (**Figure 4**). 20 of these mammals including the *Pan troglodytes*-chimpanzee (EN), *Cercopithecus erythrogaster*-white throated

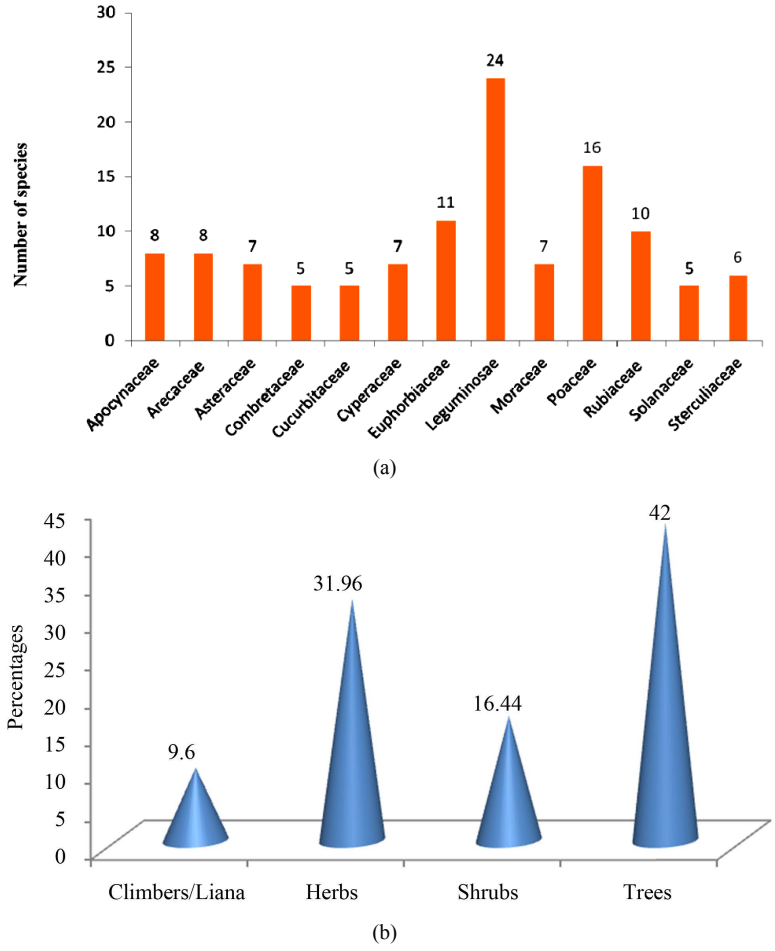

Figure 3. (a) Species composition of the most dominant plant families in the study areas; (b) Percentage contribution of different plant families (based on plant habit) to the vegetation of the study area.

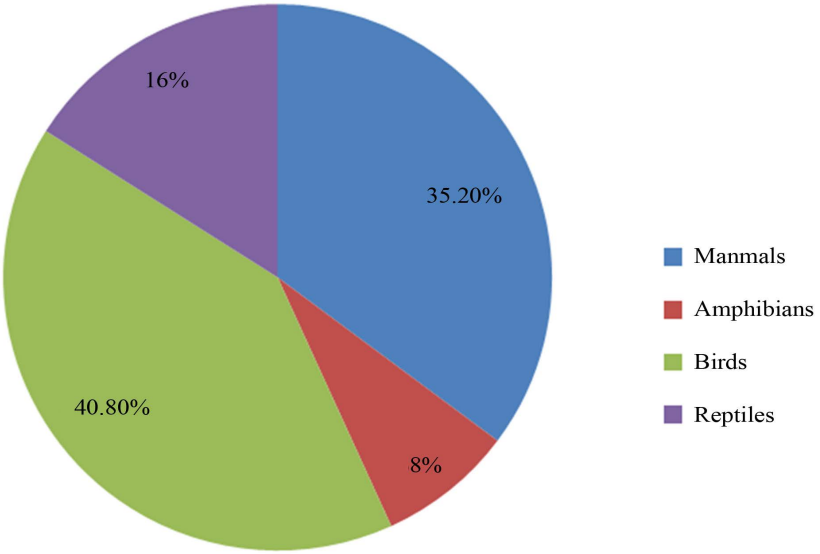

Figure 4. Percentage contribution of different wildlife groups in the study areas.

guenon (VU), *Trichechus senegalensis*-African civet (VU) and *Panthera pardus*-leopard (VU) are threatened or near threatened according to IUCN and Nigerian Conservation status. Other taxa represented in the records are 10 species of amphibians from 5 families (**Table 3**), 20 species of reptiles from 13 families (**Table 4**), and 51 species of birds from 24 families (**Table 5**). Birds accounted for 40.8% of the total faunal species in the area (**Figure 4**). 7 of the 51 species of birds, which includes grey parrot (VU), Anambra waxbill (VU) and hooded vulture (EN), are threatened. The goliath frog (an amphibian) and river turtle (reptile) are endangered, while the West African dwarf crocodile, another reptile, is vulnerable. These are threatened in line with IUCN and Nigerian Conservation status. Though the birds showed more species diversity, the amphibians were more abundant in population and *Bufo regularis* (the common African toad), was the most dominant amphibian. This species occurred in all the ecological zones. Three totems (**Table 6**), *Kinixys erosa* (serrated hinge-backed tortoise), *Python sebae* (Rock python), and *Python regius* (Royal python) were recorded.

3.3. Critical Impacts on Biodiversity of the Area

The impacts observed and recorded during the study include colossal destruction of plants and dislodgement of animals from their habitat (**Figures 2(A)-(D)**, **Figure 5(A)** and **Figure 5(B)**), creation of multiple accesses into hitherto un-accessed forests resulting in increased logging/hunting of wildlife (**Figures 2(A)-(D)**). Within the lowland tropical rainforest, the RoW has converted to derived savanna (forest fragmentation) dominated by grasses, sedges and amphibians (**Figure 2(B)**). In the freshwater swamp areas, the same RoW was observed to be route for migration of invasive alien species like water hyacinth (**Figure 5(C)**). Other terrible impacts recorded are pipeline rupture leading to spillage into water bodies and farmland, loss of aquatic flora and fauna, fire incidents, destruction of forest biodiversity, and death of humans (**Figures 5(A)-(F)**), heightened flooding and erosion due to removal of vegetal cover and disruption of hydrologic patterns, and distortion of the ecotone zone of the freshwater swamp and mangrove forests.

4. Discussion

Results obtained from this study agree with the fact that diverse ecological zones translate to diversity in species; a scenario easily adducible for the Niger Delta from information presented in **Tables 1-5**. That the Niger Delta is replete with species of plants and animals including endemic species is well documented [1] [3] [6] [31] [32]. With 219 species of plants in 66 families, and 125 different fauna species from 64 families (excluding invertebrates) from the study area, this study lays credence and strongly supports previous reports that the Niger Delta is ecologically diverse in species.

Forests in the Niger Delta are productive and sensitive ecosystems dominated by rainforest and mangrove

Figure 5. (A)-(F) Different impacts from the operational phase of the 120 km pipeline observed during the study: (A) Large scale destruction of mangroves resulting from fire incidence, which occurred after oil spillage from the pipeline; (B) Colossal kill of freshwater swamp forest and forest resources after an oil spill and fire incidence along the freshwater swamp section of the same pipeline. Notice crude oil streaming along the RoW. The RoW provides access for the streaming crude oil to freely move into water bodies, ponds, and farmlands along the course; (C) Water hyacinth (*Eichhornia crassipes*), an invasive alien species, along the RoW; (D) Stilt roots of *Rhizophora* sp. heavily covered with crude oil resulting from spillage along the mangrove section of the pipeline RoW; (E) Another section of 5A at low tide. Arrow points to pool of crude oil persisting in the mangrove "chikoko" soil two years after the spillage; (F) Farmland along the RoW, which was impacted by oil spill from the pipeline. Crops planted in the farm include cassava, yam and cocoyam. Communities along the drier section of the 120km RoW are allowed to farm beside the RoW.

Table 2. Fauna of the Study Area (Mammals).

S/no	Family	Scientific Name	Common Name	IUCN Status
1	Cercopithecidae	*Cercopithecus nictitans* (Linn, 1766)	Putty nose monkey	LC (*EN)
2	Cercopithecidae	*Cercopithecus erythrogaster* (Gray, 1866)	White throated guenon	VU
3	Cercopithecidae	*Cercopithecus mona* (Schreber, 1775)	Mona monkey	LC (*NT)
4	Cercopithecidae	*Procolobus verus* (Van Beneden, 1838)	Olive colobus	NT
5	Anomaluridae	*Anomalurus beecrofti* (Fraser, 1853)	Beecrott's flying squirrel	LC
6	Anomaluridae	*Anomalurus derbianus* (Gray, 1842)	Derby's flying squirrel	LC
7	Herpestidae	*Atilax paludinosus* (G.[Baron] Cuvier, 1829)	Marsh mongoose	LC
8	Herpestidae	*Herpestes naso* (de Winton, 1901)	Long-nosed monogoose	LC
9	Hystricidae	*Atherurus africanus* (Gray, 1842)	Brush-tailed porcupine	LC
10	Bovidae	*Tragelaphus spekii* (Speke, 1863)	Sitatunga	LC (*NT)
11	Bovidae	*Tragelaphus scriptus* (Pallas, 1766)	Bush buck	LC (*NT)
12	Bovidae	*Cephalophus maxwelli* (H. Smith, 1827)	Maxwell's duiker	LC (*NT)
13	Bovidae	*Cephalophus silvicultor* (Afzelius, 1815)	Yellow-backed duiker	LC (*NT)
14	Bovidae	*Cephalophus ogilbyi* (Waterhouse, 1838)	Ogilby's duiker	LC (*NT)
15	Bovidae	*Syncerus caffer* (Sparrman, 1779)	African buffalo	LC (*EN)
16	Nesomyidae	*Cricetomys emini* (Wroughton, 1910)	Emini's giant-rat	LC
17	Galagidae	*Galagoides demidovii* (G. Fischer, 1806)	Dwarf galago	LC
18	Muridae	*Lemniscomys striatus* (Linnaeus, 1758)	Spotted grass-mouse	LC
19	Muridae	*Mus musculus* (Linn, 1758)	House mouse	LC
20	Muridae	*Mus minutoides* (Smith, 1834)	Pigmy mouse	LC
21	Muridae	*Rattus rattus* (Linnaeus, 1758)	Black house rat	LC
22	Muridae	*Mastomys natalensis* (Smith, 1834)	Multimammate mouse	LC
23	Lorisidae	*Perodicticus potto* (Müller, 1766)	Bosman's potto	LC (*NT)
24	Lorisidae	*Arctocebus calabarensis* (J.A. Smith, 1860)	Angwantibo	LC
25	Manidae	*Manis tetradactyla* (Linn, 1766)	Long-tailed pangolin	LC (*EN)
26	Manidae	*Manis tricuspis* (Rafinesque, 1821)	Tree pangolin	NT
27	Muscardinidae	*Graphiurus hueti* Jentink, 1888	Common African dormouse	LC
28	Mustelidae	*Aonyx capensis* (Schinz, 1821)	Carpe clawless otter	LC (*NT)
29	Mustelidae	*Lutra maculicollis* (Lichtenstein, 1835)	Spotted-necked otter	LC (*VU)
30	Soricidae	*Crocidura nigeriae* (Dollman, 1915)	Nigerian musk shrew	LC
31	Suciuridae	*Protoxerus stangeri* (Waterhouse, 1842)	Giant forest-squirrel	LC
32	Suciuridae	*Heliosciurus rufobrachium* (Waterhouse, 1842)	Red-legged sun squirrel	LC
33	Suciuridae	*Funisciurus anerythrus* (Thomas, 1890)	Red-less tree-squirrel	LC
34	Suidae	*Potamochoerus porcus* (Linnaeus, 1758)	Red river-hog	LC (*VU)
35	Thryonomidae	*Thryonomys swinderianus* (Temminck, 1827)	Greater cane rate	LC

Continued

36	Tragulidae	*Hyemoschus aquaticus* (Ogilby, 1841)	Water chevrotain	LC (*DD)
37	Trichechidae	*Trichechus senegalensis* (Link, 1795)	African civet	VU
38	Vevirridae	*Viverra civetta* (Schreber, 1776)	Two-spot palm civet	LC
39	Vevirridae	*Nandinia binotata* (Gray, 1830)	Two-spot palm civet	LC
40	Vevirridae	*Genetta cristata* (Hayman in Sanborn, 1940)	Crested genet	VU
41	Vevirridae	*Genetta pardina* (Geoffrey Saint-Hilaire, 1832)	Forest genet	LC
42	Pteropodidae	*Hypsignathus monstrosus* (H. Allen, 1861)	Hammer- headed fruit bat	LC
43	Felidae	*Panthera pardus* (Linnaeus, 1758)	Leopard	NT (*VU)
44	Hominidae	*Pan troglodytes* (Blumenbach, 1799)	Chimpanzee	EN

Table 3. Fauna of the Study Area (Amphibians).

S/no	Family	Scientific Name	Common Name	IUCN Status
1	Bufonidae	*Bufo regularis* (Reuss, 1833)	African Common Toad	LC
2	Bufonidae	*Bufo maculates* (Hallowell, 1855)	Toad	LC
3	Bufonidae	*Bufo gracillipes* (Boulenger, 1899)	Toad	LC
4	Ranidae	*Rana temporaria* (Linnaeus, 1758)	Common frog	LC
5	Ranidae	*Hylarana albolabris* (Hallowell, 1856)	Frog	LC
6	Ranidae	*Rana clamitans* (Latreille, 1801)	Green frog	LC
7	Ranidae	*Ptychadenamascareniensis* (Dumeril&Bibron, 1841)	True frog	LC
8	Pipidae	*Xenopus tropicalis* (Gray, 1864)	Clawed toe frog	LC
9	Hylidae	*Hyla arborea* (Linnaeus, 1758)	Tree frog	LC
10	Conrauidae	*Conraua goliath* (Boulenger, 1906)	Goliath frog	EN

trees [3]. They are of considerable ecological importance not only because of their use as spawning and feeding grounds for many varieties of fish and shrimps but also of economic importance because forests are sources of timber, poles, fire wood, palm oil and other local food crops and medicinals. The forests support diverse wildlife species including totems as demonstrated by the results of this study. However, oil and gas exploration and production activities have over the years impacted negatively (directly and indirectly) on the biological diversity of this region resulting in increasing rate of threat to species and extinction of others (**Tables 1-5**). Opening up of landlocked rich forest ecosystems during such activities as pipeline construction encourage unsustainable forest exploitation, environmental degradation and biodiversity loss in the area. These activities accentuate flooding and flooding impacts, and the operational consequences of these pipelines, which include vandalization and oil spillage, exacerbate greenhouse gas emission and global warming. Oil spillage from oil and gas facilities and their impacts on biodiversity, soil, water, agricultural lands and humans in the Niger Delta is widely reported [33]-[38], and are confirmed by this study. That the construction and laying of flowlines/pipelines leading to the clearing of vegetation and excavation of earth has caused destruction and loss of forests and biodiversity thereby changing the landscape of the Niger Delta is not questionable. With an estimated whooping 8,778,000 stands of lowland rainforest/freshwater swamp forest trees and 864,000 stands of mangroves that were destroyed with construction and laying of pipeline along the studied 165 km stretch, the impact of the over 2000 km network of oil and gas pipelines in the Niger Delta can be imagined. This makes forest trees and plants the most affected

Table 4. Fauna of the Study Area (Reptiles).

S/no	Family	Scientific Name	Common Name	IUCN Status
1	Agamidae	*Agama agama* (Loveridge, 1923)	Agama lizard (Rainbow lizard)	LC
2	Chamaeleonidae	*Chamaeleo gracilis* (Hallowell, 1857)	Graceful chameleon	LC
3	Colubridae	*Gastropyxis smaragdina* (Schlegel, 1837)	Emerald snake	Not evaluated
4	Colubridae	*Grayia smythii* (Leach, 1818)	Smith's Water Snake	Not evaluated
5	Colubridae	*Bothropthalmus lineatus* (Schlegel, 1856)	Red lined snake	Not evaluated
6	Crocodylidae	*Osteolaemus tetraspis* (Cope, 1861)	West African dwarf crocodile	VU
7	Crocodylidae	*Crocodylus niloticus* (Laurenti, 1768)	Nile crocodile	LC
8	Elapidae	*Dendroaspis viridis* (Hallowell, 1844)	Green mamba	LC
9	Elapidae	*Naja nigricollis* (Reinhardt, 1843)	Black-necked cobra	Not evaluated
10	Elapidae	*Naja melanoleuca*	Black spiting cobra	Not evaluated
11	Elapidae	*Dispholidus typus* (A. Smith, 1829)	Boomslang	Not evaluated
12	Scincidae	*Mochlus fernandi* (Burton, 1836)	Forest skink	Not evaluated
13	Pelomeduscidae	*Pelusios niger* (Lacépède, 1788)	West African black forest turtle	LC
14	Pythonidae	*Python sebae* (Gmelin, 1788)	African Rock python	Not evaluated
15	Pythonidae	*Python reguis* (Shaw, 1802)	Royal python	LC
16	Boidae	*Calabaria reinhardtii* (Stimson, 1969)	Calabar ground python	LC
17	Testudinidae	*Kinixys erosa* (Schweigger, 1812)	Serrated hinge-backed tortoise	DD
18	Pelomedusidae	*Pelomedusa subrufa* (Lacépède 1788)	Forest turtle	LC
19	Trionychidae	*Trionyx triunguis* (Forsskål, 1775)	River turtle	EN
20	Viperidae	*Bitis gabonica* (Duméril, Bibron and Duméril, 1854)	Gabon viper	Not evaluated

biodiversity of the area. It must be stated that the removal of these trees has direct negative consequences on the wildlife, which co-habit with them; hence the number of fauna threatened with extinction in **Tables 2-5**. These fauna were automatically dislodged and or destroyed.

At present only less than 4% of Nigeria's rainforest cover is left. More frightening is the fact that the loss is still continuing at the rate of 3.5% annually [39]. This implies colossal loss of biodiversity. This study has identified oil and gas pipeline construction as major culprit in moist lowland/freshwater swamp and mangrove swamp forests destruction in the Niger Delta.

5. Conclusion

It is noteworthy that in Nigeria, oil and gas exploration and production is *sine qua non* for government earnings and therefore tied to national development. However, it has caused unimaginable destruction to biodiversity and humans, and affected means of rural livelihood. Every caution must therefore be taken to apply best practice in the business of oil and gas exploration and production as applicable in other countries. Pragmatic efforts and policies geared towards reducing land-take for pipeline construction by using existing RoW for new flowlines/pipelines must be pursued and encouraged by the appropriate government arms. The RoW width of 30 m utilized for construction of most pipelines should be reduced to between 15 m and 20 m as one of the mitigations for impacts associated with vegetation clearing and biodiversity loss. There is also need to enforce restrain on construction of pipelines across identified local biodiversity hotspots in the region. At the moment, surveillance against pipeline rupture, failure and vandalism seems to be reactionary as against realistic pragmatism. Government must therefore liaise with concerned companies to evolve functional RoW surveillance methods, which

Table 5. Fauna of the Study Area (Birds).

S/no	Family	Scientific Name	Common Name	IUCN Status
1	Accipitridae	*Gypohierax angolensis* (Gmelin, 1788)	Palm-nut vulture	LR (*NT)
2	Accipitridae	*Necrosyrtes monachus* (Temminck, 1823)	Hooded vulture	EN
3	Accipitridae	*Polyboroides radiates* (Scopoli, 1786)	Harrier hawk	LC
4	Accipitridae	*Haliaeetus vocifer* (Daudin, 1800)	West African river eagle	LC
5	Accipitridae	*Stephanoaetus coronatus* (Linnaeus, 1766)	Crown hawk eagle	NT
6	Accipitridae	*Milvus migrans* (Boddaert, 1783)	Black kite	LR (*NT)
7	Accipitridae	*Kaupifalco monogrammicus* (Temminck, 1824)	Lizard buzzard	LR (*NT)
8	Alcedinidae	*Halcyon senegalensis* (Linn, 1766)	Senegal kingfisher	LC
9	Alcedinidae	*Ceryle rudis* (Linn, 1758)	Pied kingfisher	LC
10	Alcedinidae	*Ceyx pictus* (Boddaert, 1783)	Pigmy kingfisher	LC
11	Alcedinidae	*Alcedo leucogaster* (Fraser, 1843)	White-bellied kingfisher	LC
12	Anatidae	*Dendrocygna viduata* (Linn, 1766)	White-faced tree duck	LC
13	Ardeidae	*Casmerodius albus* (Linn, 1758)	Great white egret	LC
14	Ardeidae	*Egretta garzetta* (Linn, 1766)	Little egret	LC
15	Ardeidae	*Ardea cinerea* (Linn, 1758)	Grey heron	LC
16	Ardeidae	*Ardeola ralloides* (Scopoli, 1769)	Squacco heron	LC
17	Bucerotidae	*Bycanistes fistulator* (Cassin, 1852)	Piping hornbill	LC
18	Bucerotidae	*Tockus fasciatus* (Shaw, 1811)	Black-and-white tail hornbill	LC
19	Bucerotidae	*Tropicranus albocristatus* (Cassin, 1848)	White-crested hornbill	LC
20	Bucerotidae	*Ceratogymna atrata* (Temminck, 1835)	Black-casqued hornbill	LC
21	Columbidae	*Treron australis* (Linnaeus, 1771)	Green fruit pigeon	LC
22	Columbidae	*Treron waalia* (Meyer, 1793)	Yellow-bellied fruit pigeon	LC
23	Columbidae	*Stigmatopelia senegalensis* (Linn, 1766)	Laughing dove	LC
24	Corvidae	*Corvus albus* (Müller, 1776)	Pied crow	LC
25	Cuculidae	*Centropus senegalensis* (Linn, 1766)	Senegal coucal	LC
26	Cuculidae	*Centropus leucogaster* (Leach, 1814)	Black-throated coucal	LC
27	Estrilididae	*Estrilda poliopareia* (Reichenow, 1902)	Anambra waxbill	VU
28	Hirundinidae	*Hirundo smithii* (Leach, 1818)	Wire-tailed swallow	LC
29	Hirundinidae	*Hirundo rustica* (Linnaeus, 1758)	European Swallow	LC
30	Jacanidae	*Actophilornis africana* (Gmelin, 1789)	Lilly-trotter	LC
31	Meropidae	*Merops albicollis* (Vieillot, 1817)	White-throated bee-eater	LC
32	Meropidae	*Merops hirundineus* (Lichtenstein, 1793)	Swallow-tailed bee-eater	LC
33	Motacillidae	*Motacilla flava* (Linn, 1758)	Yellow wagtail	LC
34	Musophygidae	*Corythaeola cristata* (Vieillot, 1816)	Great Blue Turaco	LC
35	Musophygidae	*Tauraco persa* (Linn, 1758)	Guinea Turaco	LC

Continued

36	Nectariniidae	*Nectarinia venusta* (Shaw & Nodder, 1799)	Yellow-bellied sun-bird	LC
37	Nectariniidae	*Nectarinia olivacea* (Smith, 1840)	Olive sun-bird	LC
38	Oriolidae	*Oriolus auratus* (Vieillot, 1817)	African golden oriole	LC
39	Oriolidae	*Oriolus brachyrhynchus* (Swainson, 1837)	Black-headed oriole	LC
40	Phasianidae	*Guttera edouardi* (Hartlaub 1867)	Crested guinea fowl	LC
41	Passeridae	*Passer griseus* (Vieillot, 1817)	Grey-headed sparrow	LC
42	Ploceidae	*Ploceus aurantius* (Viellot, 1805)	Orange weaver	LC
43	Ploceidae	*Ploceus cucullatus* (Müller, 1776)	Village weaver	LC
44	Ploceidae	*Ploceus melanocephalus* (Linn, 1758)	Black-headed weaver	LC
45	Ploceidae	*Ploceus nigerrimus* (Vieillot, 1819)	Vieillot's black weaver	LC
46	Ploceidae	*Malimbus scutatus* (Cassin, 1849)	Red-vented malimbe	LC
47	Psittacidae	*Psittacus erithacus* (Linnaeus, 1758)	Grey parrot	VU
48	Pycnonotidae	*Pycnonotus barbatus* (Desfontaine, 1789)	Common garden bulbul	LC
49	Scolopacidae	*Tringa hypoleucos* (Linns, 1758)	Common sand piper	LC
50	Turdidae	*Cercotrichas galactotes* (Temminck, 1820)	Rufous-tailed Scrub Robin	LC
51	Viduidae	*Vidua macroura* (Pallas, 1764)	Pin-tailed whydah	LC

Table 6. Wildlife Species Considered totem, or associated with taboos in the study area.

Family	Scientific Name	Common Name
Varanidae	*Kinixys erosa*	Serrated hinge-backed tortoise
Pythonidae	*Python sebae*	Rock python
Pythonidae	*Python regius*	Royal python

EN = Endangered, VU = Vulnerable, LR/NT = Lower Risk/Near Threatened, LR/CD = Lower Risk/Conservation-Dependent, LC = Least Concern, DD = Data Deficient.

will completely eliminate pipeline vandalisation and its attendant consequences. This should as much as possible include robust education and awareness campaigns on the impacts of pipeline vandalization on biodiversity and humans. Where possible, the use of RoW for farming should be encouraged with extreme caution and supervision.

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