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Anthropogenic Impacts on Niger River Basin Environment in High Guinea

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Abstract: Generally speaking, there has been a consensus on the primary drivers of anthropogenically induced environmental degradation. However, little progress has been made in determining the magnitude of these impacts, particularly in developing countries. The aim of this study therefore, is to ascertain, the degree of anthropogenically induced environmental impacts on the Niger river in high Guinea. The results show that only three variables; population, anarchistic exploitation and urbanization were statistically significant and that the regression model accounts for 60% of the variation in the environmental impacts. Moreover, the degradation of water quality is a significant problem for the Niger river in high Guinea. The growth of large cities along the river's banks has not been accompanied by development of wastewater collection and treatment plants, be it for domestic or industrial wastewater. We established, a water sampling protocol for the soil and climate conditions found in high Guinea that would allow us to analyze concentrations (parts billion^{-1}) of trace elements and TSS in the waters of the Niger river. The enrichment factor calculated for these trace elements compared with international standards allows a preliminary estimate of contamination from anthropogenic sources. The primary causes of degradation are to be sought in a strong entropic pressure on the anarchistic exploitation of the renewable and non-renewable natural resources, which have been worsened by the past 25 years of dryness. Mining, fishing, animal husbandry and other aspects of agriculture, appear among the main causes of environmental degradation.

Key words: Environmental degradation, urbanization, river banks, water contamination, anarchistic exploitation, population growth

INTRODUCTION

The idea that population growth affects environmental resources and human welfare is as old as civilization. Population has been recognized as one of the key driving forces of environmental change bringing along economic activities such as, technology, politics and economic institutions, as well as varied attitudes and beliefs (Dietz and Rosa, 1994).

There is no doubt that population development and environmental quality are interconnected. This fact is expressed by a fundamental identity formulated by Ehrlich *et al*. (1971), who stated that the number of people living in an area determines the level of environmental degradation, due to such factors as their anarchistic exploitation of resources and the implementation of technology. This implies that the magnitude of the human induced threat to the ecosystem and banks of the Niger river is linked to human population size and resource use per person. In turn, resource degradation is accelerated by population growth due to rising levels of per capita income, consumption habits, technological development, social organization and resource management (Nwafor, 2006; Ignatius, 2009). As aptly put by Rosa *et al*. (2004), an unintended consequence of industrial development and the simultaneous rapid growth in both population and economic out put per capita has caused the unprecedented growth in global environmental impacts.

Environmental damage threatens all humanity although, people living in developing countries are often the most vulnerable to its effects. This is due to the fact that a large proportion of the population is directly dependent on primary economic activities for their survival and well being. In Niger river Basin for instance, is known for its rapid population growth and concentration of people in few localities. This has strained the traditional system of: agriculture, hunting and fishing anarchistic, bust fires, mining and brick production, resulting in environmental degradation. Furthermore in the attempt to diversify the economy, rapid industrialization has taken place in the country without adequate consideration given to environmental concerns (Nwafor, 2006). There has also, been a concentration of

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both population and economic activities in some states at the expense of others with the former experiencing pressure on environmental resources. These account for the linkages between population density, anarchistic exploitation of resources and environmental degradation on the Niger river (Sadoff and Grey, 2002).

There is evidence to show that some aspects of human well being can be improved with minimal environmental impacts. For instance, Dietz *et al*. (2007) has shown that although urbanization, economic structure, age distribution and life expectancy are among the anthropogenic drivers of environmental impacts, they have little or no effect on environmental degradation. This, according to them is because findings suggest that while, increasing affluence does drive impacts, it is possible to improve on other aspects of human well being without adverse environmental effects. A pertinent issue therefore is whether, this situation is the same in Guinea and other developing countries. A doubt has however been raised in this regard by Rosa *et al*. (2004), who argued that despite the pivotal role human factors play in environmental degradation, uncertainties and contradictions about them persist. Against the foregoing, the aim of this research is to determine the strength and direction of anthropogenic drivers of environmental change on the Niger River in high Guinea. This is necessary because as noted by Dietz *et al*. (2001), although, there appears to be scientific consensus on the primary drivers of anthropogenic environmental degradation for well over a decade, little progress has been made in determining the precise relationship between drivers and impacts.

This creates a gap in knowledge, which constitutes a significant barrier in identifying policies that have the most potential for reducing human impacts on the environment. According to Nwafor (2006), the filling up of such a knowledge gap will enable policy makers, project proponents, environmental authorities and other stakeholders to fully appreciate environmental concerns and give them due weight. More importantly, the study is significant because it elucidates the applicability of environmental impact.

MATERIALS AND METHODS

The data for this study were obtained from three sources. The population data were obtained from the general census of the total population and distribution by sex: estimate 2007, while the data for the water flow in the basin, average height of water per day and TSS were obtained by researchers documented calculations. Finally, the data for the number of industrial establishments were obtained by using the following apparatuses: GPS Magellan, Apparatus of photography, Dictaphone and surveys through closed questionnaires (2007). It should be noted that the Niger River Basin in high Guinea is divided into 7 prefectures. Accordingly, the data were all aggregated for the 7 prefectures and the capital Conakry. The altitude, the heights and the instantaneous flows of certain tributaries were determined, as well as the number of brick production furnaces and all these data were reported by means of tables. In short, the localization was carried out each time after a documentary exploitation near the prefectural, communal authorities and the local community. The characteristics of banks and of modern and artisanal mining along the rivers above made it possible to confirm their current level of degradation.

RESULTS AND DISCUSSION

The Niger River Basin area in high Guinea, stretching from the highlands of Guinea down to the delta in Nigeria, represents about 4% of the total area of the basin (Fig. 1). However, the basin is a spinal column for the economy of Guinea. Communities living within and around the basin are heavily reliant on the environmental products and services provided by the river, which also supports 243 fish species (including 20 endemic species) and provides vital stop-over sites for millions of migratory birds.

Major environmental degradation in the Niger River Basin results from either natural or anthropogenic causes. Natural causes relate to climatic variability and change, in particular the decrease in rainfall in the basin since, the late 1970s. The major anthropogenic cause is land degradation via deforestation, which has taken place in the watershed in large part because of increased demographic pressure (Andersen *et al*., 2005).

Four principal environmental issues; land degradation, water degradation, deforestation and biodiversity loss have a synergistic effect on water resources in the basin. Land degradation in the form of erosion results from inappropriate agricultural practices, such as bush fires also termed slash and burn in an attempt to clear fields for rice paddies and other extensive cultivation as well as overgrazing, which leads to the reduction of wetlands through drainage (Table 1a and b). Water degradation, mainly the deterioration of water quality, results from point-sources such as pesticides and fertilizers used in agriculture and from non-point-sources such as urban pollution generally through lack of sanitation infrastructure (sewerage). Deforestation is the result of increased needs for energy and limited access to electricity; people in the Basin use wood and charcoal for domestic purposes (which also, contributes to land degradation). Biodiversity loss is caused by habitat destruction and a subsequent increase of invasive species, which are in turn caused by inappropriate fishing

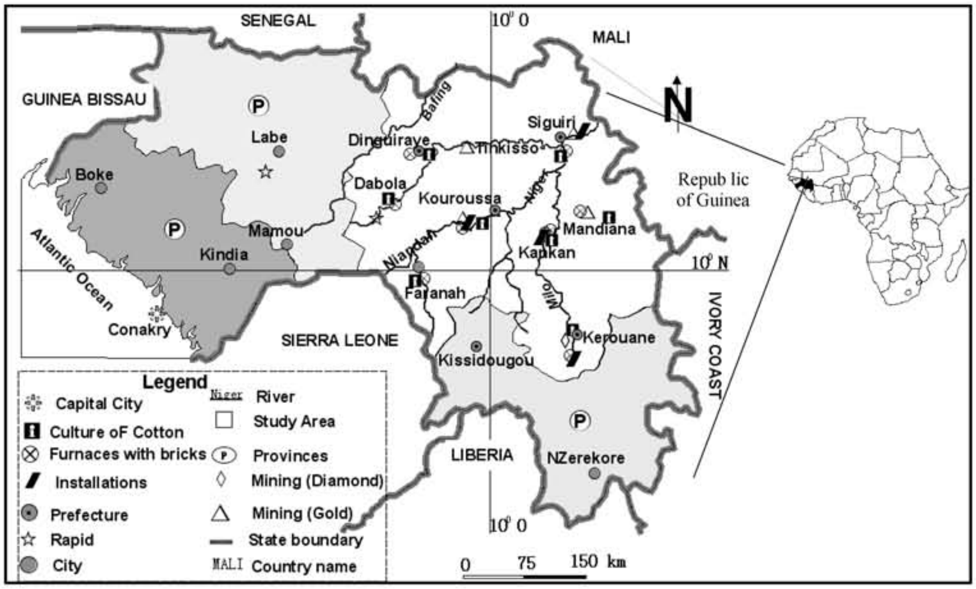

Fig. 1: The Niger River Basin in high Guinea

Table 1a: Agricultural production 2000

	Rice		Corn		Groundnut	
Prefectures	Ha	Tons	Ha	Tons	Ha	Tons
Kankan	45.650	86.735	5.848	7.602	6.072	9.351
Kerouane	20.533	32.853	688.000	826.000	30.000	42.000
Kouroussa	26.793	35.099	5.926	8.060	7.261	7.842
Mandiana	13.914	24.489	22.011	35.217	8.060	11.042
Siguiri	12.092	19.105	12.439	15.549	5.362	7.507
Dabola	11.211	18.947	5.145	5.659	5.011	6.464
Dinguiraye	15.129	28.140	17.695	18.580	9.465	12.873
Faranah	19.650	38.710	807.000	1.210	2.510	3.188
Kissidougou	34.458	74.430	7.980	12.768	2.948	3.951
Beyla	38.012	69.941	254.000	381.000	1.092	1.267
Total	237.442	428.449	78.793	105.852	47.811	63.527

Table 1b: Agricultural production 2001

	Fonio		Manioc	
Prefectures	Ha	Tons	Ha	Tons
Kankan	6.769	6.972	16.885	136.766
Kerouane	2.699	3.401	3.108	23.028
Kouroussa	3.286	2.563	4.254	29.353
Mandiana	2.728	2.264	3.974	34.179
Siguiri	1.013	1.023	2.647	20.591
Dabola	6.930	7.623	904.000	6.970
Dinguiraye	4.629	6.342	1.142	8.933
Faranah	4.264	5.074	664.000	5.279
Kissidougou	1.932	2.241	1.709	14.849
Beyla	4.155	4.570	1.899	17.209
Total	38.405	42.073	37.186	297.157

practices, deforestation and land conversion for agriculture. It is necessary to also, note the mining, which may attack the ground, under ground and vegetable cover, the aggression of the banks and the heads of sources (Fig. 2-4).

This thorough degradation of the ecosystems of the catchment area of Niger River led to the disappearance or reduction of certain animal and vegetable species. This has affected the quality, the quantity and the availability of the biological diversity of these ecosystems to be

Fig. 2: Diamond mining site from Foulifimba (Sonaferiya) Banankoro to Kerouane; lack of rehabilitation of the grounds has contributed to the vast level of soil erosion

Fig. 3: The depredated banks of the Milo river

Fig. 4: Mud tank of Slams Dam, Factory DMS AREDOR on the new banks of the new bed of baoule (Milo) several times moved for the industrial exploitation of diamond to Gbenko, Korean Detruisant thus of the watery ecosystemand and decreasing the flow of water in the river

preserved. These reductions and disappearances also caused problems of poverty to the communities who are the users of these resources (Koranteng, 2001).

The booming population growth is the main cause of the environmental degradation, due to human activities such as: the construction of houses and factories and agricultural activities (York *et al*., 2003). Therefore, a combination of human population growth (on average 3% year^{-1}), unsustainable resource use and development and decertification is threatening the Niger River's ecosystems ability to supply critically needed natural resources to the people of Niger Basin in high Guinea. River flow in the basin is decreasing and fishing pressure is increasing, leading to drastic declines in production of fisheries. Deforestation and farming of fragile soils contribute to erosion through sedimentation in river channels. Waterborne diseases have increased and invasive aquatic species have spread, choking river channels.

Indeed, this situation resulted in a generalized and accelerated impoverishment of bordering populations. In our investigation concerning the brick production

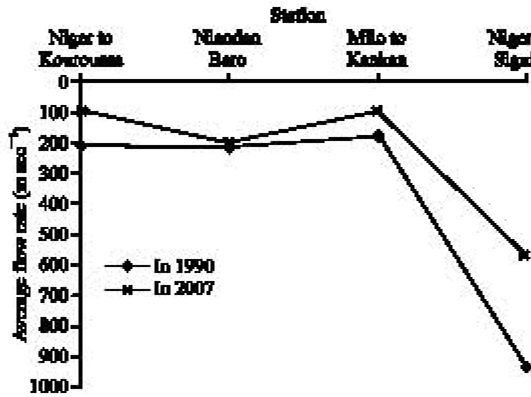

Fig. 5: Furnaces with brick (cooked) number Variation from 1990-2007

evaluation, we found that the Niger River basin experienced population increase of >50% between 1990 from 1,286,000, 000 inhabitants to 2,242,718 inhabitants in 2007 (Table 2).

During recent decades, civil war and unrest in several countries that border the Niger Basin have made it the recipient of large numbers of people displaced by violent conflict, adding pressures and stresses to already fragile lands. For example, in 2003 >25,000 refugees settled in the Fouta Djallon and Mount Nimba regions of Guinea. This led to increased degradation of the highlands, with rapid deforestation and associated land degradation, soil erosion, gullying and loss of productive lands. Loss of absorption capacity causes rapid runoff, with the consequences downstream of high sedimentation, siltation of existing infrastructure, floods and changes in river flows (Gans and Jost, 2005).

The anarchistic exploitation of the resources of the basin slopes and the effect of the natural phenomena led to a trend in reduction flows, heights and instantaneous speeds of these rivers. This is why nowadays the majority of these rivers tare for the period of low water level contributing to the total degradation of the quality of the hydrous resources, principal resource of provisioning of the populations of drinking water and resources holidic (Fig. 5 and Table 3-7).

Thus, one observed on Syncaryon this case of rather significant variations of flow over a period of approximately 20 years. The annual average, which was of 340 m^3 sec^{-1} (1973-1980) has gone down to 190 m^3 sec^{-1} (1980-1989) which indicates a reduction of about 50% of the total flow (Bamba *et al*., 1996).

Figure 2 shows, the variation of the number of brick furnaces within the 7 various prefectures of the Niger Basin in high Guinea. This economic activity has a very disastrous impact on the current state of the degradation of the river's banks. Collected statistics of this activity give us an idea of the width by area. It is also, at the base of the widening of the beds of the rivers by the loam pits open on the banks whose widening reaches 10-15 m place^{-1}. It contributes to the destruction of the forest by the wood cut for the cooking of bricks (Fig. 6-8).

The results also, show that at any of the stations of the upper basin, titanium, aluminum, iron, zirconium, other yttrium, strontium, lead, uranium and vanadium can be considered as earth elements, coming from the weathering of silicate rocks. These elements are correlated to one and to Total Suspended Solids (TSS) (Andersen *et al*., 2005). According to Ahearn *et al*. (2005), population

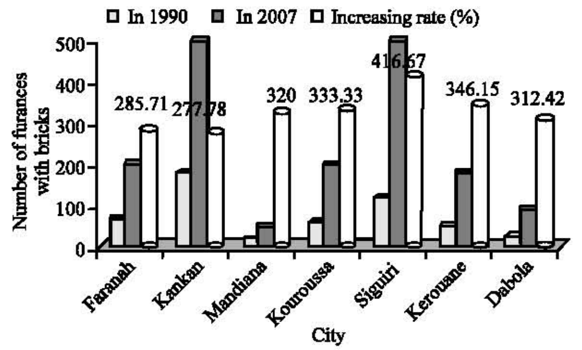

Fig. 6: Furnace with Bricks cooked on the banks of Milo contributing to the river environmental pollution and the stranding of Niger and its affluents to Kankan

Table 2: Total population and distribution by sex: estimate 2007

Prefectures	Population total	Rural population	Urban population	Density by km^2	Men	Women
Beyla	166.214	151.944	14.270	23	85.114	81.100
Dabola	147.963	116.946	30.017	35	71.979	75.985
Dinguiraye	169.273	126.291	42.982	31	82.166	87.107
Faranah	196.432	138.114	58.317	17	97.935	98.496
Kankan	351.019	213.732	137.287	20	173.842	177.177
Kerouane	205.357	172.730	32.627	23	107.680	97.677
Kissidougou	258.865	164.342	94.523	54	126.478	132.387
Kouroussa	198.538	178.771	19.767	13	96.066	102.471
Mandiana	228.727	215.412	13.315	19	112.881	115.846
Siguiri	320.330	278.070	42.260	33	157.130	163.200

These data are drawn from the general census of the population and the habitat (1996)

Table 3: Results of attitude, hight evarge per day and flow of catchment area

		Heights average per day (cm)			Flow (m³/s)		
Catchment area	Altitude (m)	Min. instantaneous	Between	Maxi. instantaneous	Min. instantaneous	Between	Max. instantaneous
Niger to Faranah	417	-	64-599	-	-	1,2-233	-
Niger to Kouroussa	355	-	47-581	-	5,8	-	-
Milo to Kankan	361	21	-	-	1,6	-	-
Milo to Kérouané	-	46	-	-	9	-	-
Niandan to Baro	-	-	-	640	-	-	1190
Niandan to Kissidougou	478	-	-	535	1,9	-	250
Sankarani to Mandiana	354	43	-	624	9,50	-	946
Tinkisso to Dabola	-	-	-	514	0,46	-	756
Dion to Baranama	-	30	-	-	11	-	-

Table 4: Contains the monthly average values of the flow of the tributary rivers of the catchments area of Niger in the 2007

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
17.5	7.47	3.12	1.760	6.410	11.10	42.3	148.0	222.0	187.0	74.6	32.90
49.6	24.00	12.20	7.800	11.200	30.20	104.0	514.0	-	-	-	-
19.2	4.53	2.84	-	18.100	21.50	132.0	-	-	376.0	98.7	32.40
20.6	10.70	11.70	17.100	18.800	26.10	55.5	149.0	-	-	-	-
-	-	-	-	-	-	-	570.0	947.0	609.0	234.0	95.30
-	-	-	6.000	11.500	27.20	-	84.3	128.0	90.3	50.9	22.30
65.7	30.80	13.80	19.900	16.200	22.00	82.2	594.0	898.0	643.0	193.0	72.70
-	-	-	0.584	0.584	1.79	108.0	57.5	55.8	51.8	12.5	5.93
30.8	20.30	20.40	25.100	21.800	25.90	57.5	21.3	-	-	-	-

Author's research

Table 5: Mean monthly flows at the four main branches of the Niger River in Guinea (cubic m sec^{-1})

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Avg. year
Niger to Kouroussa	52.6	25.4	13.5	8.76	12.3	57.4	180	414.000	682.000	595.000	299.000	112	232
Niandan to Baro	49.1	26.3	17.0	14.60	30.5	108.0	257	464.000	679.000	544.000	282.000	103	215
Milo to Kankan	35.2	20.0	14.4	16.00	29.2	81.6	229	439.000	599.000	412.000	179.000	70	177
Niger to Siguiri	200.0	103.0	58.6	44.00	67.1	231.0	804	2.054	3.304	2.708	1.244	454	948

Andersen *et al*. (2005)

Table 6: Monthly and annual flow of the Milo at Kankan (high Guinea) from 1947-2000 (cubic m sec^{-1})

Years	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1947	45.70	23.10	19.80	6.870	18.60	108.0	298.0	453	766	388	125.0	60.3	193
1948	33.10	14.80	7.69	9.020	33.20	117.0	419.0	569	628	267	186.0	73.0	196
1949	41.00	24.70	28.50	34.000	33.90	37.0	229.0	599	763	348	162.0	70.5	198
1950	52.00	35.80	21.40	13.100	30.00	45.2	200.0	271	533	547	198.0	73.5	168
1951	45.00	31.60	28.90	29.500	76.10	142.0	397.0	604	641	697	531.0	146.0	281
1952	77.30	45.50	36.40	30.600	36.90	73.8	243.0	598	685	585	221.0	94.1	227
1953	64.60	31.00	29.70	19.900	27.40	172.0	347.0	595	688	469	198.0	105.0	229
1954	61.30	42.10	35.20	49.500	60.90	155.0	407.0	599	678	622	379.0	151.0	270
1955	80.60	44.30	48.60	46.300	69.90	205.0	413.0	598	737	620	237.0	125.0	269
1956	68.00	46.20	44.00	46.900	39.20	64.4	167.0	308	509	367	139.0	77.0	156
1957	39.60	21.60	20.20	15.600	29.40	87.7	276.0	471	712	629	244.0	104.0	221
1958	55.20	34.20	18.00	39.400	99.30	275.0	286.0	195	605	461	219.0	132.0	202
1959	57.00	30.60	18.20	13.600	32.70	72.6	351.0	325	787	327	188.0	73.6	190
1960	34.30	16.90	9.51	19.900	51.40	124.0	270.0	720	828	511	219.0	89.8	241
1961	45.40	25.40	12.20	11.300	34.10	35.1	183.0	363	484	297	123.0	53.4	139
1962	28.40	14.80	11.90	20.000	42.70	72.8	254.0	459	774	560	268.0	111.0	218
1963	53.00	45.30	32.50	31.000	55.40	62.2	192.0	404	662	516	180.0	68.1	192
1964	32.70	17.80	10.10	10.900	16.80	103.0	173.0	498	506	429	164.0	121.0	174
1965	65.80	40.50	30.00	18.400	36.60	136.0	421.0	267	565	309	137.0	56.4	174
1966	16.50	11.80	8.84	11.400	25.80	86.3	232.0	461	375	391	184.0	63.7	156
1967	30.50	17.30	13.30	15.500	32.80	55.8	255.0	534	751	706	227.0	88.4	227
1968	43.30	26.00	16.30	21.300	38.20	209.0	200.0	530	571	382	210.0	105.0	196
1969	59.30	37.70	35.80	31.600	27.80	103.0	441.0	757	786	654	355.0	121.0	284
1970	67.20	38.70	36.70	41.400	39.70	73.6	167.0	399	613	280	139.0	76.4	164
1971	44.30	33.40	21.30	25.900	38.70	54.4	167.0	455	598	341	115.0	76.2	164
1972	34.40	20.80	12.20	27.800	59.90	178.0	292.0	470	585	359	138.0	79.7	188
1973	36.40	18.40	9.33	10.800	13.80	44.3	93.2	450	545	303	173.0	57.1	146
1974	32.10	15.20	10.90	10.100	9.52	27.7	290.0	467	795	464	145.0	56.8	194
1975	29.50	15.80	8.47	21.600	42.50	88.9	238.0	504	773	498	145.0	66.8	203
1976	39.10	21.70	12.70	12.500	41.40	66.7	178.0	374	517	616	412.0	109.0	200
1977	62.30	34.40	18.00	11.500	16.70	51.6	146.0	274	561	270	97.9	44.7	132
1978	21.20	13.90	9.03	23.800	32.30	152.0	247.0	456	654	453	203.0	73.5	195
1979	43.40	21.10	15.60	25.200	24.90	101.0	439.0	693	656	476	205.0	76.2	231
1980	45.20	32.20	15.90	10.300	24.80	55.1	111.0	361	470	200	135.0	64.6	127
1981	34.80	19.80	12.20	15.800	42.50	51.7	357.0	694	634	279	106.0	49.7	191
1982	24.40	14.40	8.55	20.700	53.00	67.6	253.0	428	518	272	127.0	47.2	153
1983	23.20	13.20	5.63	5.990	15.20	115.0	183.0	406	518	285	103.0	44.5	143
1984	20.10	8.18	5.49	5.860	22.00	51.6	123.0	481	355	215	73.5	29.7	116
1985	10.20	4.06	2.18	2.600	5.09	16.4	170.0	603	680	332	95.1	35.8	163
1986	14.60	5.98	3.05	3.630	8.75	16.7	97.3	361	556	274	124.0	38.8	125
1987	17.80	8.99	3.73	2.410	5.39	62.5	174.0	366	484	322	82.3	44.5	131
1988	15.20	5.15	2.67	1.990	2.18	13.6	76.4	362	513	169	60.8	22.4	104
1989	5.73	3.44	2.18	1.180	4.52	30.8	95.4	327	460	332	81.8	31.0	115
1990	9.70	3.05	1.25	1.480	15.70	31.0	101.0	335	407	220	80.7	33.3	103
1991	14.60	7.40	3.90	2.120	17.20	68.9	136.0	349	379	350	103.0	38.0	122
1992	10.10	4.70	1.49	0.594	6.43	68.9	186.0	351	448	222	103.0	30.3	119
1993	9.14	3.62	1.67	7.610	9.10	31.0	111.0	431	445	279	146.0	44.2	127
1994	8.70	2.50	0.80	0.600	1.60	49.9	122.0	242	707	574	331.0	67.6	176
1995	19.20	4.50	2.80	7.700	18.10	21.5	132.0	346	493	376	98.7	32.4	129
1996	10.40	4.90	6.00	12.300	18.30	59.6	125.0	296	658	708	432.0	96.2	202
1997	31.20	8.20	1.70	0.400	9.10	67.6	250.0	452	719	299	95.5	32.3	164
1998	6.40	2.10	0.30	0.300	13.90	68.7	193.0	546	588	377	86.9	28.3	159
1999	21.60	9.67	4.93	5.130	8.31	11.2	66.1	107	594	478	165.0	50.8	127
2000	11.10	2.10	0.10	0.900	7.40	68.0	417.0	166	370	526	146.0	37.3	146
Average	35.20	20.00	14.40	16.000	29.20	81.6	229.0	439	599	412	179.0	70.0	177

Andersen *et al.* (2005)

density also contributed to TSS loading, which has an impact on water quality. Indeed, enrichment factors for strontium are very significant at Banankoro (Table 8).

Fertilizers used have an impact on water quality as nitrate contaminate water. The impact of cotton farming in high Guinea on wells, pasture and surface water in the Syncaryon, Milo, Niger, Niandan, Tinkisso watershed was studied. Traces of pesticides were found, but not in significant amounts. Nitrates, nitrites, phosphates and ammonia were consistently present at several sites, sometimes over the maximum allowed limits. Thus, it is becoming acknowledged that water is likely to be the most pressing environmental concern of the next century (Wolf *et al*., 1999).

In the past 20 years, Guinea has experienced intense exploitation of its gold resources and currently produces

Table 7: Niger River monthly and annual flow at siguiri (high Guinea) from 1950-1999 (cubic m sec^{-1})

Years	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1950	184	111	60.30	43.90	63.20	116.0	630.000	1.930	3.770	3.650	1.480	469.000	1.050
1951	241	145	108.00	74.90	198.00	432.0	1.240	2.680	3.820	3.700	3.640	1.130	1.460
1952	477	266	148.00	89.40	92.10	185.0	1.030	2.340	3.400	3.690	1.490	550.000	1.150
1953	320	176	132.00	89.90	110.00	605.0	1.680	3.300	4.350	3.720	1.540	684.000	1.400
1954	379	226	146.00	155.00	186.00	528.0	1.540	2.910	4.530	3.470	2.220	1.130	1.460
1955	483	264	197.00	148.00	198.00	704.0	1.720	3.120	4.710	4.280	1.970	879.000	1.560
1956	440	252	166.00	129.00	91.60	206.0	857.000	1.710	3.640	3.090	1.170	525.000	1.020
1957	260	134	85.90	48.50	66.30	307.0	1.190	2.680	4.470	4.680	2.390	794.000	1.430
1958	400	219	104.00	117.00	261.00	783.0	967.000	1.370	3.340	3.190	1.680	960.000	1.120
1959	403.0	210.0	109.00	65.10	87.50	360.0	1.270	2.180	4.470	2.760	1.330	519.000	1.150
1960	247.0	123.0	70.80	54.40	85.90	312.0	1.060	3.050	4.490	3.420	1.530	558.000	1.250
1961	263.0	128.0	66.90	41.80	74.60	107.0	841.000	2.270	3.410	2.070	771.000	308.000	866.000
1962	145.0	72.0	39.90	32.50	90.10	214.0	953.000	2.710	5.300	4.060	1.900	732.000	1.360
1963	338.0	208.0	109.00	63.50	116.00	146.0	669.000	1.990	3.390	4.110	1.690	522.000	1.120
1964	239.0	113.0	56.80	38.80	48.30	453.0	1.070	2.430	3.760	3.570	1.140	643.000	1.130
1965	333.0	171.0	108.00	82.60	89.70	336.0	1.420	2.040	3.460	2.980	1.220	421.000	1.060
1966	192.0	128.0	84.50	74.50	71.80	164.0	498.000	2.200	3.200	3.410	1.570	537.000	1.020
1967	245.0	135.0	91.20	52.40	100.00	1510.0	766.000	2.480	4.780	5.740	2.060	696.000	1.450
1968	350.0	194.0	113.00	81.70	122.00	769.0	933.000	2.520	3.260	2.620	1.270	635.000	1.070
1969	275.0	136.0	87.10	66.10	60.40	306.0	1.570	2.850	5.040	4.830	3.030	759.000	1.590
1970	348.0	176.0	99.80	76.90	62.70	147.0	491.000	1.960	3.540	1.910	828.000	397.000	838.000
1971	160.0	66.9	42.80	34.50	57.20	133.0	686.000	3.120	3.940	2.240	700.000	440.000	973.000
1972	155.0	78.9	39.40	51.00	112.00	214.0	1.210	1.890	2.830	2.230	925.000	443.000	881.000
1973	163.0	76.6	35.10	31.30	36.00	159.0	326.000	1.890	2.490	1.480	822.000	242.000	648.000
1974	106.0	50.6	30.50	22.90	26.50	86.7	1.010	2.440	4.370	3.140	922.000	308.000	1.050
1975	128.0	67.4	30.60	26.50	71.50	183.0	1.100	2.130	3.910	3.430	1.230	435.000	1.070
1976	162.0	78.1	41.30	24.60	65.10	242.0	681.000	2.090	2.820	3.650	2.810	741.000	1.120
1977	313.0	138.0	75.00	35.10	36.30	113.0	416.000	1.220	2.400	1.810	664.000	237.000	623.000
1978	108.0	67.2	45.70	44.70	60.20	385.0	837.000	1.730	3.230	2.590	1.090	361.000	882.000
1979	162.0	64.4	29.20	24.80	32.70	317.0	1.450	3.000	2.940	2.240	1.080	370.000	982.000
1980	161.0	80.2	34.30	16.50	28.90	97.0	331.000	1.480	2.540	1.180	816.000	349.000	593.000
1981	135.0	65.4	26.10	30.20	127.00	182.0	948.000	2.340	2.990	1.990	697.000	249.000	819.000
1982	112.0	55.2	28.30	29.80	89.60	178.0	682.000	1.580	2.260	1.410	721.000	219.000	616.000
1983	94.0	46.8	26.20	18.50	25.90	295.0	692.000	1.490	2.440	1.610	544.000	194.000	626.000
1984	82.5	38.3	21.90	16.40	44.40	125.0	529.000	1.710	1.490	1.310	438.000	160.000	499.000
1985	65.6	29.3	11.80	8.08	9.54	22.8	472.000	1.970	2.940	1.820	491.000	165.000	670.000
1986	61.0	24.8	8.51	6.11	9.90	32.4	238.000	1.280	2.760	1.690	614.000	185.000	577.000
1987	72.1	32.7	9.09	4.39	7.85	192.0	469.000	1.370	2.090	1.950	673.000	218.000	594.000
1988	78.7	32.6	10.30	6.11	4.52	32.8	346.000	1.580	2.840	1.130	417.000	132.000	551.000
1989	47.7	19.5	8.65	6.58	7.22	59.6	235.000	1.090	2.020	1.620	510.000	204.000	486.000
1990	68.8	22.3	9.60	6.93	20.60	64.3	399.000	1.446	2.144	1.451	538.000	195.000	531.000
1991	73.0	22.1	10.40	8.24	7.25	72.5	437.000	1.418	2.008	1.587	679.000	217.000	545.000
1992	82.3	32.2	12.10	7.40	6.87	105.0	567.000	1.341	2.135	1.379	554.000	190.000	534.000
1993	75.8	25.8	15.40	11.20	13.60	75.5	317.000	1.494	1.889	1.424	775.000	281.000	533.000
1994	96.0	34.8	16.80	10.30	10.80	196.0	731.000	1.876	3.580	3.218	2.179	531.000	1.040
1995	190.0	81.9	32.80	30.00	50.40	134.0	443.000	2.209	3.771	3.028	1.179	400.000	962.000
1996	155.0	83.5	31.40	21.40	49.30	156.0	529.000	1.752	3.180	2.620	967.000	313.000	822.000
1997	121.0	55.0	19.90	12.50	30.00	154.0	711.000	1.532	2.807	2.068	944.000	322.000	731.000
1998	121.0	51.4	23.90	12.60	21.00	176.0	614.000	2.133	3.062	2.484	881.000	270.000	965.000
1999	106.0	44.4	19.90	13.30	16.70	49.0	380.000	1.370	3.171	2.675	1.445	467.000	941.000
Average	200.0	103.0	58.60	44.00	67.10	231.0	804.000	2.054	3.304	2.708	1.244	454.000	948.000

Andersen *et al.* (2005)

Table 8: Annual discharge of TSS in the Niger to Banankoro (high Guinea)

Banankoro	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Flow (103 ton $year^{-1}$)	338.0	411.0	467.0	800.0	862.0	596.0	479.0
Flow (m sec^{-1})	531.0	521.0	521.0	1,070.0	977.0	825.0	729.0
TSS (mg L^{-1})	20.1	25.1	28.4	23.7	27.9	22.9	20.8
Ts (ton/km^2/year)	4.8	5.8	6.6	11.3	12.1	8.4	6.7

Andersen *et al.* (2005), T_S (transport specifique) is the annual discharge of TSS divided by the basin area

tonnages per year in Siguiri, Kouroussa and Mandiana. Gold development has contributed to several environmental problems and in particular those pertaining to water resources. In the gold mines these environmental problems are usually caused by accidental pollution and by illegal siphoning. Studies have indicated that >1 million litters of cyanide have been spilled into the environment (Fig. 9). In addition to gold development; the exploitation of other mineral resources is an environmental threat in the basin.

Fig. 7: Loam pit for bricks at the edge of the Milo River in Kankan widening the bed of the river

Fig. 8: Sight of the basin of leaching in heap by cyanide of the industrial exploitation of gold often overflowed on the banks of koba with Koron by the SAG with Siguiri (Destroying the ecosystems in the Niger River)

Fig. 9: Average annual flow rate of Niger River: four main branches in 1990 and 2007

CONCLUSION

This study has firmly established that population and anarchistic exploitation of resources are the most important drivers of environmental impacts on Niger River Basin in high Guinea.

It has also shown that urbanization influences environmental change in Guinea on the Niger River although its effect is negative; implying that modernization, which is associated with it brings about a reduction on environmental impacts. The negative influence of urbanization in Kankan and Siguiri, the more urbanized prefectures in the Niger Basin were found to have higher environmental impacts because of the cumulative effects of other drivers of environmental change namely population, anarchistic exploitation of resources, which captures the effect of population density as well as the technological impact.

The implication of the findings on the environment sustain ability on the Niger River in high Guinea is that appropriate measures should be put in place to reduce the impacts of the anthropogenic drivers on the environment. In addition, the substantial amount of the technological impact on the environment requires that urgent attention be paid on the measures to improve on the efficiency exploitation of gold in Guinea. This will help reduce the deterioration of the water quality in the Niger Basin.

Within sight of these degradations and taking into account the fact that among the rivers, some are trans-border it is time to make provisions allowing a rational and durable exploitation of these basins slopes and their resources in the interest of all the generations.

REFERENCES

Ahearn, D.S., R.W. Sheibley, R.A. Dahlgren, M. Andersonb, J. Johnson and K.W. Tate, 2005. Land use and land cover influence on water quality in the last free-flowing river draining the western Sierra Nevada, California. Elsevier J. Hydrol., 313: 234-247. DOI: 10.1016/j.jhydrol.2005.02.038. www.elsevier.com/locate/jhydrol.

Andersen, I., O. Dione, M.J. Holder and J.C. Olivry, 2005. The Niger River Basin A Vision for Sustainable Management. In: Katherin George Golitzen (Ed.). The International Bank for Reconstruction and Development/The World Bank, pp: 66-67, 92-119. DOI: 10-15961978-0-8213-62037. ISBN: 978-0-8213-6203-7.

Bamba, F., M. Diabate, G. Mahe and M. Diarra, 1996. Rainfall and Runoff Decrease of Five River Basins of the Tropical Upstream Part of the Niger River over the Period 1951-1989. In: Roald, L.A. (Ed.). Global Hydrological Change, XXIst General Assembly, European Geological Association, The Hague, the Netherlands, May 6-10. ISBN: 0821362038. http://vertigo.revues.org/index2038.html.

Dietz, T., R. York and E.A. Rosa, 2001. Ecological democracy and sustainable development. Paper Presented at the 2001 Open Meeting of the Human Dimensions of Global Environmental Change Research Community, Rio de Janeiro, Brazil, http://sedac.ciesin.columbia.edu/openmeeting/downloads/1006029486.

Dietz, T. and E.A. Rosa, 1994. Rethinking the environmental impacts of population, Affluence and technology. Human Ecol. Rev., 1: 277-300. www.awi.uni-heidelberg.de/with2/Discussion%20papers/papers_2003_2005/dp422.pdf.

Dietz, T., E.A. Rosa and R. York, 2007. Driving the human ecological footprint. Frontiers in Ecol. Environment. Ecol. Soc. Am., 5 (1): 13-18. DOI: 10.1890/1540-9295(2007)5[13:DTHEF]2.0.CO;2.http://www.esajournals.org/doi/abs/10.1890/1540.

Ehrlich, P. *et al*., 1971. Impact of Population Growth Science, 171 (3977): 1212-1217. DOI: 10.1126/science.171.3977.1212. http://www.sciencemag.org/cgi/content/citation/171/3977/1212.

Gans, O. and F. Jost, 2005. Decomposing the impacts of population growth on environmental. Deterioration. In: Discussion Paper Series No. 422. University of Heidelberg, Department of Economics. http://www.awi.uni-heidelberg.de/with2/Discussion%20papers/papers_2003_2005/dp422.pdf.

Ignatius, A.M., 2009. The impacts of anthropogenic factors on the environment in Nigeria. J. Environ. Manage., 90 (3): 1422-1426. DOI: 10.1016/j.jenvman.2008.08.009.

Koranteng, K.A., 2001. Diversity and stability of demersal species assemblages in the gulf of Guinea. West Afr. J. Applied Ecol., 2: 49-63. http://hdl.handle.net/1834/1265.

Nwafor, J.C., 2006. Environmental Impact Assessment for Sustainable Development: the Nigerian Perspective. Enugu: Environment and Development Policy Centre for Africa (EDPCA) Publications.

Rosa, E.A., R. York and T. Dietz, 2004. Tracking the anthropogenic drivers of ecological Impacts. Ambio J. Human Environ., 33 (8): 501-512. DOI: 10.1579/0044-7447-33.8.509. PMID: 15666682. http://www.bioone.org/doi/abs/10.1579/0044-7447-33.8.509.

Sadoff, C. and D. Grey. 2002. Beyond the River, the Benefits of Cooperation on International Rivers. Water Policy, 4 (5): 389-403. DOI: 10. 1016/S1366-7017(02)00035-1.

Wolf, A., J. Natharius, J. Danielson, B. Ward and J. Pender, 1999. International River Basins of the World. Int. J. Water Resources Dev., 15 (4): 387-427. DOI: 10.1080/07900629948682. http://www. informaworld.com/smpp/content~content=a713672437~db=all~order=page.

York, R., E. Rosa and T. Dietz, 2003. Bridging environmental science with environmental policy: plasticity of population, affluence and technology. Soc. Sci. Quart., 83 (1): 18-34. DOI: 10.1111/1540-6237.00068. http://www3.interscience.wiley.com/journal/118946191/abstract?CRETRY=1&SRETRY=0.