Volta River Basin

A Programme of the Governments of the Volta River Countries, with the assistance of the Global Environment Facility (the United Nations Environment Programme)

Volta River Basin Preliminary Transboundary Diagnostic Analysis

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1.0 Introduction

1.1 TDA Content and Process

According to GEF guidance, the purpose of conducting a Transboundary Diagnostic Analysis (TDA) is to scale the relative importance of sources and causes, both immediate and root, of transboundary 'waters' problems, and to identify potential preventive and remedial actions. The TDA provides the basis for development of both the National Action Plans (NAPs) and the Strategic Action Programme (SAP) in the area of international waters of the GEF.

This TDA, therefore, summarizes information available from the region, gathered both as part of ongoing national activities within the littoral states, as well as information made available from a variety of internationally supported activities in the region.

The methodology for a TDA consists of the following steps, at a minimum:

- Identification of major perceived problems and issues, including status and gaps
- Classification as national or transboundary in nature
- Causal chain analysis (including root causes)
- Identification of interventions to address the root causes and primary perceived problems and issues

Because the list of possible interventions and actions arising from the analysis of the Volta River Basin problems is so large, a mechanism was needed in order to prioritize the interventions. Borrowing from methodology commonly used in the European Union and other regions, the present TDA identifies a series of Environmental Quality Objectives (EQOs), which represent the regional perspective of major goals for the regional environment. The use of EQOs helps to refine the TDA process by achieving consensus on the desired status of the Volta River Basin. Within each EQO (which is a broad policy-oriented statement), several specific targets were identified. Each target generally had a timeline associated with it, as well as a specific level of improvement or target status. Thus, the targets illustrate the chain of logic for eventual achievement of the EQO. Finally, specific interventions or actions were identified to permit realization of each of the targets within the designated time frame.

In summary, this TDA follows the GEF TDA Guidelines for International Waters projects. However, an additional step was achieved, that is, the use of EQOs to facilitate consensus on the desired state of the Volta River Basin after the next pentade or decade. The EQOs naturally led to the identification of specific targets to be met within the desired time frame, which then led to the identification of specific interventions and actions that can be considered in the framework of the NAPs and SAP.

1.2 Scope of the TDA

The present analysis covers the six countries that are located in the Volta River Basin: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, and Togo. Many institutions and experts participated

in the development of this TDA by assisting in the drafting of national reports. At least three workshops, including one national, were held in each of the six countries to gather input for these reports. Additionally, two meetings for national coordinators and two meetings for steering committee members were held on the Volta River Basin. While much data were obtained through this process, only partial information on the environmental status was provided by each country, so this TDA is a summary of available information only. Where possible, additional sources of data were sought.

This Preliminary TDA is drawn from the Draft Preliminary TDA prepared by Dr. Yaw Opoku-Ankomah, national reports from the participating countries, and various technical publications available for the region prepared by UNEP, ACOPS, and other organizations. The major sources of information are listed in the bibliography accompanying this TDA. Gaps in information available for this Preliminary TDA can be filled during the full GEF project.

This Preliminary TDA identifies the following list of major perceived problems and issues:

1. Land degradation
2. Water scarcity
3. Loss of biodiversity
4. Flooding
5. Water-borne diseases
6. Growth of aquatic weeds
7. Coastal erosion
8. Water quality degradation

Below, each of these problems and issues is addressed from a status perspective. It answers the questions: What do we know about each problem/issue? What data support the quantification of the extent of the problem/issue? Do the data support these as real problems and issues, or just as perceptions? This analysis took place on a scientific level, including biological, hydrological, physical, social, and other perspectives on the problem. This is in effect the "status" assessment.

The next step was to perform the causal chain analysis; the major perceived problems and issues were analyzed to determine the primary, secondary and root causes for these problems/issues. Identification of root causes is important because root causes tend to be more systemic and fundamental contributors to environmental degradation. Interventions and actions directed at the root causes tend to be more sustainable and effective than interventions directed at primary or secondary causes. Because the linkages between root causes and solutions of the perceived problems are often not clear to policymakers, however, interventions commonly are mistakenly directed at primary or secondary causes.

This Preliminary TDA attempts to clarify the linkages between root causes and perceived problems to encourage interventions at this more sustainable level. Fortunately, a number of different perceived problems and issues have the same root causes so addressing a few root causes may have positive effects on several problems and issues.

This Preliminary TDA faced several challenges, including a lack of complete information and data, a short time frame for its final preparation, and limited time in the Region.

2.0 Biogeophysical and Socio-Economic Setting of the Volta River Basin

2.1 Biogeophysical Characteristics

Physical Features

The Volta River Basin is the 9th largest in sub-Saharan Africa with an estimated area of 400,000 km^2. The Volta basin stretches from approximately latitude 5 ^{0} 45' N in Ghana to 14 ^{0}N in Mali. The widest stretch is from approximately longitude 5^{0}W to 2^{0}E along latitude 11^0 N, but the basin becomes more narrow towards the coast of the Gulf of Guinea. The Volta basin is spread over six West African countries (Figure 2.1-1 in Appendix D.)

The distribution of the area of the basin among the six riparian countries is shown in Table 2.1-1, below.

Table 2.1-1. Distribution of the Basin Among the Six Riparian Countries.

Country	Area Of Volta River Basin (km^2)	% Of Basin	% Of Country In Basin
Benin	17,098	4.10	15.2
Burkina Faso	178,000	42.65	63.0
Côte d'Ivoire	12,500	2.99	3.9
Mali	15,392	3.69	1.2
Togo	26,700	6.40	47.3
Ghana	167,692	40.18	70.0
Total	**417,382***	**100%**	

Figures for the area of the Volta River Basin are from respective National Reports. The areas recorded from the country reports are quite similar to those quoted from Moniod, et al. (1977). The slight differences may be due to the scale of the topographic sheet used in estimating the area or some changes in the geomorphology of the basin.

As Table 2.1-1 indicates, the relative proportion of a basin area found within a country does not necessarily reflect the relative importance of that part of the basin in that country. While a country may only have a small percentage of the total basin within its borders, as in the case of Togo, this area might comprise a significant proportion of the entire country. Additionally, the area of the country within the basin might hold an abundance of natural resources with respect to the entire country, such as in the case of Mali. Thus this project is of comparable importance for each of the six riparian countries.

2.1.1 Relief

The basin is flanked by a mountain chain on its western-most section. From the sea and north-eastwards rises the Akwapim ranges, followed by Togo Mountain, Fazao Mountain, and the Atakora ranges in Benin. The Kwahu plateau branches north-westwards after the Akosombo Gorge. The only other significant relief on the western part of the basin is the plateau of Banfora.

The basin in general has a low relief with altitudes varying between 1 and 920 m. The average mean altitude of the basin is approximately 257 m, with more than half the basin in the range of 200 – 300 m. The global slope index is between 25 – 50 cm/km. Some of the characteristics of the relief are shown in Table 2.1-2.

Table 2.1-2. Some Important Relief Characteristics

Elevations at MSL (m)	Black Volta	White Volta	Oti	Main Volta
Minimum altitude	60	60	40	1
Maximum altitude	762	530	920	972
Average altitude	287	270	245	257

ORSTOM Hydro. Monographs edited by Moniod et al., 1977.

2.1.2 Geology and Soils

The geology of the main Volta is dominated by the Voltaian system. Other geological formations include the Buem formation, Togo series, Dahomegan formation, and Tertiary-to-Recent formations. The Voltaian system consists of Precambrian to Paleozoic sandstones, shales and conglomerates. The Buem series lies between the Togo series in the east and the Voltaian system in the west. The Buem series comprises calcareous, argillaceous, sandy and ferruginous shales, sandstones, arkose, greywacke and agglomerates, tuffs, and jaspers. The Togo series lies to the eastern and southern part of the main Volta and consists of alternating arenaceous and argillaceous sediment. The Dahomeyan system occurs at the southern part of the main Volta Basin and consists of mainly metamorphic rocks, including hornblende and biotite, gneisses, migmatites, granulites, and schist.

The Oti Basin is underlain mainly by the Voltaian system, the Buem formation and the Togo series.

The White Volta Basin is composed of the Birimian system and its associated granitic intrusives and isolated patches of Tarkwaian formation. The other significant formation is the Voltaian system. The Birimian system consists of metamorphosed lavas, pyroclastic rocks, phyllites, schists, tuffs, and greywackes.

The Black Volta Basin consists of granite, the Birimian and Voltaian systems, and, to a minor extent, the Tarkwaian system. The Tarkwaian formation consists of quartzites, phyllites, grits, conglomerates, and schists.

The underlying rocks of the basin have no inherent porosity. Thus, groundwater storage occurs only in fractured zones of the rocks.

2.1.3 Hydrogeology

As discussed above, the geological characteristics of the basin show that the rocks have no inherent porosity. Formation of aquifers, therefore, depends upon secondary porosity created as a result of fissuring or weathering. Weathering is a consequence of circulation of water through joints, fractures, and quartz veins which had formed earlier in the rocks. Muscovite or hornblende can weather to approximately 30 m, whereas the Birimian formation can weather to a depth of approximately 73 m, thus giving rise to a thicker aquifer. The hydrogeological

characteristics are presented in Table 2.1-3. See Figure 2.1-2 in Appendix D for a map of the geology of the Volta River Basin.

Table 2.1-3. Hydrogeological Characteristics of the Basin

	Run-off Coefficient (%)	Borehole Yields (m^3/h)	Mean Borehole Yields (m^3/h)	Specific Capacities ($m^3/h/m$)	Depths to Aquifer (m)	Mean Depth to Aquifer (m)	Depth of Boreholes (m)	Mean Depth of Borehole (m)
White Volta	10.8	0.03 – 24.0	2.1	0.01 – 21.1	3.7 – 51.5	18.4	7.4 – 123.4	24.7
Black Volta	8.3	0.1 – 36.0	2.2	0.02 – 5.28	4.3 – 82.5	20.6		
Oti	14.8	0.6 – 36.0	5.2	0.06 – 10.45	6.0 – 39.0	20.6	25.0 – 82.0	32.9
Lower Volta	17.0	0.02 – 36.0	5.7	0.05 – 2.99	3.0 – 55.0	22.7	21 – 129.0	44.5

Tabulated from MWH, 1998

The table indicates that run-off coefficients are in general low. This means that direct recharge of aquifers from precipitation is less than 20% across the basin. These figures do not give a good outlook for recharge of the groundwater resources.

The borehole yields are quite variable with a mean for all the sub-basins between 2.1 and 5.7 m^3/h. These figures suggest that the groundwater yields in the basin are low.

Specific capacity is a measure of transmissivity of the aquifers. High specific capacity indicates a high coefficient of transmissivity and similarly, a low specific capacity indicates low transmissivity. The figures in the table show that the region has low hydraulic transmissivity.

The depth of aquifers is also variable in the basin. Studies have shown that there is no correlation between depths to aquifer and borehole yields (WARM, 1998).

The results indicate that groundwater resources are not abundant in the basin and face threats if not properly managed.

2.1.4 Soils

The geology, relief, and climate of locations interact to produce soils of typical characteristics. The soils of the Main Volta Basin in the sub-humid Savannah Zones are Savannah Ochrosols, Groundwater Laterites, Savannah Ochrosols – Groundwater Laterite (GWL), Savannah Ochrosol – GWL Intergrades, Savannah Ochrosol – Rubrisol Intergrades, Tropical Black Clays, Alluviosols, Tropical Grey Earths, Sodium Vleisols, and Savannah Gleisols.

The major soil groups in the Black and White Volta are Savannah Ochrosols, Groundwater Laterites, Savannah Ochrosols – Groundwater Laterite Intergrades, Savannah Lithosol, Savannah Gleisols, Savannah Ochrosols – Rubrisol Intergrades, and Savannah Gleisol – Alluviosol Intergrades.

The soils of the Oti Basin are Savannah Ochrosols, Groundwater Laterites, Savannah Ochrosol-GWL Intergrades, Savannah Lithosols, Savannah Gleisols, and Forest Lithosols.

Table 2.1-4. Identified Soil Groups in the Basin

Soil Group	Predominant Relief	Predominant Texture	Erosion Hazard
Savannah Ochrosols	Upper and middle slopes gently undulating	Moderately heavy to light	Moderate sheet and gully erosion
Groundwater Water Laterites (GWL)	Near level to level lower slopes to valley bottoms	Light over concretions and Ironpan	Severe to very severe sheet erosion
Savannah Ochrosols GWL Intergrades	Gently undulating to level middle to lower slopes	Medium to light	Moderate to severe sheet erosion
Savannah Lithosols	Summits with steep slopes	Medium to light	Severe gully erosion
Savannah Gleisols (GLE)	Near-level to level lowlands	Moderately heavy to very heavy	Slight sheet erosion
Savannah GLE-Alluviosol Intergrades	Lowland terraces	Light to very light	Moderate to slight sheet erosion

2.1.5 Climate

The climate of the region is controlled by two air masses: the North-East Trade Winds and the South-West Trade Winds.

The North-East Trade Winds, or the Harmattan, blowing from the interior of the continent, are dry. In contrast, the South-West Trade Winds, or the monsoons, are moist since they blow over the seas. The interphase of these two air masses is called the Inter-tropical Convergence Zone (ITCZ). There is a lot of convective activity in the region of the ITCZ, hence the region is associated with a considerable amount of rainfall. The ITCZ moves northwards and southwards across the basin from about March to October when rainfall is received in the region.

Three types of climatic zones can be identified in the region: the humid south with two distinct rainy seasons; the tropical transition zone with two seasons of rainfall very close to each other; and, the tropical climate, north of lat 9° N, with one rainfall season that peaks in August. Average annual rainfall varies across the basin from approximately 1600 mm in the southeastern section of the basin in Ghana, to about 400 mm in the northern part of Mali.

The annual mean temperatures vary from about 27° C to 30° C. Daily temperatures can be as high as 32° C - 44° C, however, whereas night temperatures can be as low as 15° C. The humidity varies between 6% and 83% depending on the season and the location.

There have been a number of changes in the precipitation patterns of some sub-catchments in the basin, as rainfall and run-off reductions have been evident since the 1970s (Opoku-Ankomah, 2000). Some areas that used to have bi-modal type of rainfall have only one mode as the second minor season has become very weak or non-existent. This situation means that rainfed agriculture can only be carried out once instead of twice a year.

It has been estimated that 340 km^3 of rain must fall on the catchment before run-off occurs at significant levels. Once this threshold has been reached, approximately half of the precipitation becomes run-off. This indicates that only small changes in rainfall could have dramatic effects on run-off rates. Although rainfall decreased by only 5% from 1936 to 1998, run-off decreased by 14% (Andreini, 2000).

Simulations of run-off using GCM-based climate scenarios developed by Minia (1998) showed 15.8% and 37% reduction in run-off of the White Volta Basin for the years 2020 and 2050, respectively (Opoku-Ankomah, 2000). These projections showed that projects whose design was based on historical records without considering climate change, such as the hydropower dam at Akosombo, could be vulnerable.

2.1.6 Hydrology

The basin is drained by several major rivers: the Black Volta, the White Volta with the Red Volta as its tributary, the Oti River and the Lower Volta. The mean annual flows of the Black Volta, White Volta, and Oti River are 8,300 x 10^6, 8,180 x 10^6, and 12,606 x 10^6, respectively (MWH, 1997). The Oti River with only about 18% of the total catchment area contributes between 30% and 40% of the annual flow of the Volta River System. This situation is due to the steep topography and the relatively high rainfall in the Oti sub-basin.

The Oti River begins in the Atakora hills of Benin at an altitude of about 600 m and flows through Togo and Ghana. In Benin, the Oti River is referred to as the Pendjari River. Tributaries include the Koumongou, Kéran, Kara, Mô, Kpanlé, Wawa, Ménou, and Danyi Rivers. Due to the regularization by the Kompienga Dam in Burkina Faso, the Oti River has a permanent flow with an annual average flow of 100 to 300 m^3/s, and can reach more than 500 m^3/s. Virtually all of the tributaries stop flowing during the dry season, however, and their annual average flows are only in the range of 5 m^3/s.

The White Volta begins as the Nakanbé River in Burkina Faso. The Red Volta, referred to as Nazinon in Burkina Faso, and Sissili, are tributaries of the White Volta and they all have their source in Burkina Faso. The mean annual flow of the White Volta Basin is estimated to be about 300 m^3/s where the percentage of flow from outside Ghana to the total flow is estimated to be 36.5%.

The Sourou from Mali and the Mouhoun from Burkina Faso join in the latter country and flow downstream to Ghana as the Black Volta. In Burkina Faso, apart from the Mouhoun, all of the rivers, including the Nakanbé, Nazinon and Sissili, dry up for approximately two months out of the year. The mean annual flow of the Black Volta at Bamboi is about 200 m^3/s, out of which about 42.6% originates from outside Ghana.

In Ghana, the Black Volta, the White Volta and the Oti join the main Volta at Volta Lake, which was created by the Akosombo Dam.

Table 2.1-5. Catchment Areas and River Lengths in Burkina Faso

Catchment	Surface	Length
Mouhoun (Black/Volta)	75,800	997
Sourou	15,200	284[a]
Nakanbé (White Volta)	41,000	592
Nazinon (Red Volta)	11,200	343
Sissili	7,450	184
Pendjari (Oti)	21,600	503[b]

a: The Sourou, before joining the Mouhoun, begins in Burkina Faso then flows through Mali and then flows through Burkina Faso

b: Calculated as leaving the source while passing through Burkina Faso all the way down to the Togo-Benin border.

Table 2.1-6. Area Coverage of Volta River Basin

	Area in Ghana (km^2)	Area Outside Ghana (km^2)	Total Area (km^2)
Black Volta	35,107	113,908	149,015
White Volta	45,804	58,945	104,749
Daka	9,174	-	9,174
Oti	16,213	56,565	72,778
Lower Volta	59,414	3,237	62,651
Todzie/Aka	1,865	363	2,228
Songhor	115	-	115
Total	**167,692**	**233,054**	**400,710**

Table 2.1-7. Catchment Areas and River Lengths of Black Volta and Main Tributaries in Ghana

Catchment	Area (km^2)	Length (km)
Black Volta	33,000 (142,060)*	1,360
Benchi	1,450	100
Chuko	1,670	90
Chiridi	350	70
Oyoko	640	60
Laboni	3,270	160
Gbalon	1,490	60
San	390	40
Pale	1,030	60

Catchment	Area (km^2)	Length (km)
Dagere	340	40
Aruba	460	40
Kule	480	40
Bekpong	380	30
Kuon	290	40
Kamba	1,310	60
Tain	6,340 (7,200)*	210

( )* Total area including catchment outside Ghana

Table 2.1-8. Catchment Areas and River Lengths of White Volta and Main Tributaries in Ghana

Catchment	Area (km^2)	Length (km)
White Volta	49,230 (106,740)*	1,140
Tamne	880	50
Morago	620 (1,610)*	80
Mole	5970	200
Kulpawn	10,600 (10,640)*	320
Sisili	5,180 (8,950)*	310
Red Volta	590 (11,370)*	310
Asibilika	1,520 (1,820)*	100
Agrumatue	1,410 (1,790)*	90
Nasia	5,240	180
Nabogo	2,960	70

( )* Total area including catchment outside Ghana

Table 2.1-9. Catchment Areas and River Lengths of Oti and Main Tributaries in Ghana

Catchment	Area (km^2)	Length (km)
Oti	16,800 (75,110)*	940
Bonjari	890	70
Afram	11,400	320
Obosom	3,620	120
Sene	5,370	210
Pru	8,730	300
Kulurakun	5,930	180
Daka	8,280	430
Asukawkaw	2,230 (4,780)*	180
Mo	680 (5,160)*	210

( )* Total area including catchment outside Ghana

Table 2.1-10. Catchment Areas and River Lengths in Togo

Name	Surface of the Basin (km^2)	Length (km)	Flow (m^3/s)
Kara	9,460 (Kara, Kpessidé, and N'Maboupi)	230	56.6
Mô	3,175 (route Sokodé – Bassar and Bougoulou)	160	75
Kéran	9,165 (Titira and Naboulgou)	85	17.7
Oti	54,750 (Mango)	185	123
Sansargou	2,240 (Borgou)	-	4.39
Kama	202 (Bassar)	-	4.42
Binah	690 (Pouda)	60	-
Kpélou	417	-	16
Koumongou	6,730 (Koumongou)	-	106
Kpaya	394 (Atchangbade)	-	34.4
Koulougouna	990	40	6.03
Danyi	52 (Dzobegan)	-	2.03

Source: Annales hydrologiques de l'ORSTM 1983 à 1987 (données de 1987)

* Calculations carried out by Dr. GNONGBO, University of Lome from the topographic maps at a scale of 1/200,000; sheets of Dapaong, Kara, Sokodé and Atakpamé.

The estimation of direct recharge in the Volta River system is based on the assumption that recharge occurs when actual evapotranspiration and direct run-off are balanced by precipitation. This occurs when the soil is saturated to the field capacity, which is likely to occur when precipitation exceeds evapotranspiration. Analyses of rainfall data from various stations within the Volta River system indicate that the months in which precipitation exceeds the evapo-transpiration are usually June, July, August, and September. The annual recharge for the Volta River system ranges from 13.4% to 16.2% of the mean annual precipitation. On average, the mean annual recharge of the Volta River system is about 14.8% of the mean annual precipitation.

2.1.7 Dams and Reservoirs

Throughout the Volta River Basin, dams and reservoirs have been created in order to mobilize water for agricultural, industrial, and electricity-generating purposes. The amount of these large and small dams continues to expand as population pressure grows. Increasing use of these waters and decreasing precipitation in the region, however, threaten continued sustainable management of the waters in the basin. Figure 2.1-3 in Appendix D indicates the location of dams in the Volta Basin.

Several large dams have been constructed throughout the Volta River Basin with the primary purpose of generating electricity. The damming of the Volta River at Akosombo has created one of the largest man-made lakes in the world, covering an area of approximately 8500 km^2. A smaller and shallower impoundment, the Kpong Headpond, covering an area of roughly 38 km^2 with a storage capacity of 2000 x $10^6 m^3$, was completed in 1981 when another hydroelectric dam was constructed at Kpong, 20 km downstream of Akosombo.

Benin has a hydroelectric power station on the Oti River with a storage capacity of 350 million m^3 and the capacity to produce 15 MW. Additionally, a hydroelectric power station is planned at Pouya (Natitingou) on the Yéripao.

In recent decades there has been a great push in Burkina Faso to expand the number of dams in the Volta River Basin and, as a result, there are now approximately 600 dams and lakes with a total storage capacity of 4.7 billion m^3. The volume stored annually in these reservoirs is 2,490 billion m^3.

Cote d'Ivoire does not have any major dams in the Volta Basin since their basin is small and is on the border with Ghana. The following minor dams are located in Cote d'Ivoire.

Table 2.1-11. Information on Dams in the Volta Basin of Cote d'Ivoire

Name of the Dam	Year	Manager	North	West	Use	Surface of the Basin (km^2)	Height of the Dike (m)	Storage Capacity (1000 m^3)
Sorobango	1994	Sodepra	8°09	2°43	Livestock	2,50	4,75	30
Kamala	1994	Sodepra	8°24	2°44	Livestock	3,00	5,00	36
Yerekaye	1994	Sodepra	8°21	2°49	Livestock	7,00	4,50	64
Kiendi	1994	Sodepra	8°11	2°42	Livestock	6,00	5,00	73
Poukoube	1994	Sodepra	8°23	2°42	Livestock	6,00	5,00	30
Tambi	1994	Sodepra	8°13	2°35	Livestock	6,00	4,50	37
Borombire	1989	Sodepra	8°44	3°08	Livestock	4,00	4,25	73
Imbie	1988	Sodepra	9°13	2°54	Livestock	5,50	3,90	73
Lankara	1988	Sodepra	9°11	3°02	Livestock	5,00	4,25	73
Niandegue 2		Sodepra	9°13	2°54	Livestock		5,00	73
Syaledouo	1988	Sodepra	9°03	3°01	Livestock	4,50	4,25	73
Tidio	1980	Prive	9°16	2°57	Livestock		4,50	73
Angai	1988	Sodepra	9°35	3°17	Livestock	4,50	4,25	73
Bikodidouo	1983	Sodepra	9°34	3°04	Livestock	6,00	4,25	73
Bouko	1990	Sodepra	9°28	3°13	Livestock	4,00	4,20	73
Bouna	1979	Sodepra	9°17	2°58	Livestock	6,00	4,00	73
Bromakote	1988	Sodepra	9°21	3°03	Livestock	9,50	4,25	73
Danoa	1990	Sodepra	9°41	3°16	Livestock	7,00	4,25	73
Gnonsiera	1990	Sodepra	9°37	3°04	Livestock	5,00	4,05	73
Kalamon	1988	Sodepra	9°48	3°10	Livestock	7,50	4,25	73
Kodo	1980	Sodepra	9°41	3°18	Livestock	6,00	4,00	73
Kpanzarani	1988	Sodepra	9°25	3°05	Livestock	5,00	4,00	73
Kpoladouo	1988	Sodepra	9°30	3°19	Livestock	5,00	4,25	73
Nambelessi	1988	Sodepra	9°32	3°18	Livestock	5,00	4,20	73

Name of the Dam	Year	Manager	North	West	Use	Surface of the Basin (km^2)	Height of the Dike (m)	Storage Capacity ($1000\ m^3$)
Niamoin	1982	Sodepra	9°37	3°27	Livestock	7,00	4,25	73
Niandegue 1	1982	Sodepra	9°16	2°54	Livestock	6,00	4,25	73
Peko	1983	Sodepra	9°31	3°02	Livestock	5,50	4,25	73
Piri	1991	Sodepra	9°29	3°11	Livestock		5,00	73
Sepedouo	1982	Sodepra	9°40	3°24	Livestock	5,00	3,50	73
Sipe		Sodepra	9°40	3°24	Livestock			73
Sipirition	1983	Sodepra	9°25	2°54	Livestock	5,50	4,25	73
Tchassondouo	1988	Sodepra	9°35	3°25	Livestock	5,50	4,25	73
Timperdouo	1990	Sodepra	9°32	3°11	Livestock	10,00	4,25	73
Didre Douagre	1990	Sodepra	9°43	3°21	Livestock	5,00	4,25	73
Minichio	1990	Sodepra	9°46	3°29	Livestock	6,00	3,90	73
Nankele	1990	Sodepra	9°52	3°23	Livestock	9,00	4,25	73
Nikindjoka	1990	Sodepra	9°43	3°17	Livestock	4,00	4,20	73
Peon	1990	Sodepra	9°45	3°24	Livestock	4,00	4,00	73
Tinkalamon		Sodepra	9°49	3°38	Livestock	5,50	4,20	73
Yalo	1982	Sodepra	9°48	3°24	Livestock	7,00	4,25	73
Boromeredouo	1989	Sodepra	8°59	3°08	Livestock	4,00	4,25	73
Yonodouo			8°59	2°57	Livestock	5,60	4,25	73
Barriera	1982	Sodepra	9°53	3°27	Livestock	6,00	4,25	73
							Total	**2,971**

In the Volta Basin in Mali, Pont-barrage of Baye is the only significant dam.

Togo has the following dams in the Volta Basin.

Table 2.1-12. Information on Dams in the Volta Basin of Togo

Dam	Volume (m^3)	Uses
Dalwak	10,000,000	Domestic water supply, irrigation
Tantiégon	762,400	Agriculture, animal husbandry, domestic water supply
Namiété	600,000	Domestic water supply, animal husbandry market garden
Magna	500,000	Domestic water supply, animal husbandry, market gardening
Kozah	5,000,000	Domestic water supply, animal husdandry

Although there are believed to be hundreds of dams in the Volta River Basin, the data on the locations and size of these waterworks are inadequate. Thus, it is difficult to quantify the effects of the dams on the Volta River Basin.

2.2 Ecosystems

Four main types of ecosystems can be identified in the Volta Basin (Moniod et al., 1977). Additionally, a coastal ecosystem can be found where the Volta River enters the ocean.

2.2.1 The Short Grass (Steppe) Vegetation

This zone is located in the extreme northwest region of the White Volta, covering some parts of Burkina Faso and Mali. With only a minimal amount of rainfall of between 150 and 500 mm annually, this zone can also be described as the Sudano-Sahelian sector. Trees and shrubs are rare in this ecosystem, but a few tree species, such as Baobab, can be found.

2.2.2 Woody and Shrub Savannah, Open Forest of Dry Type

This ecosystem is found in the northern and middle sudan. The strands of forest are open and the vegetation is generally dry. The zone covers parts of the Sourou Basin, northern White Volta, Oti, Red Volta, and Black Volta basins. Thus, this ecosystem covers a significant part of Burkina Faso and the northern parts of Togo and Benin.

2.2.3 Woody and Shrub Savannah, Open Forest of Humid Type

This ecosystem covers the southern sudan sector. The vegetation occupies the southwestern region of Burkina Faso and greater parts of Ghana, Togo, and Benin. Rainfall in this zone is between 1000 – 1300 mm annually. The zone is marked by forest galleries of thick vegetation along river channels where adequate moisture is available. The tall trees found in the forest galleries include the following: *Cola laurifolia, Pterocarpus, Santalinoides, Cynometra magalophylla,* and *Parinari congenis*. In areas where trees have been felled at unsustainable levels followed by incessant bushfires, few trees remain.

The following species are more commonly found in this ecosystem than in others: *Burkea africana, Isoberlina doka, Isoberlina dolziellii, Detarium microcarpum.* Other species unknown in the Woody and Shrub Savannah dry type, such as *Uapaca togoensis, Parinari polyandra, Syzyglum guineense, Lohira lanceolata, and Cussonia barteri*, are found in this system.

In the southern part of this zone, a transition from the dry forest-belt to the dense rainforest occurs.

2.2.4 Dense Forest

The dense forest vegetation type is dependent upon abundant rainfall in the region. Since the vegetation is also dependent upon soils, climate, and other factors, the vegetation in the region is not uniform. In the dense forest zone, the following species are found: *Milicia excelsa, Khaya grandifoliola, Terminalia, Distemomanthus, Benthamianum, Pycnanthus angolensis, Triplochiton scleroxylon,* and *Antiaris africana*. The National Park of Kéran in Togo is located in this ecosystem.

2.2.5 Coastal Ecosystem

The Volta River delta, containing lagoons and mangroves, serves as an additional ecosystem. The delta contains both open and closed lagoons as drought and reduction or cessation of flooding due to the Aksombo Dam have isolated parts of the system, causing them to behave like closed lagoons. This area contains Ghana's most species-diverse mangrove forest, which is located at the mouth of the river and serves as a nursery site for commercial marine fishes and shrimps. The Volta River, including its delta, is a globally significant habitat for migrating birds and, as a result, the Keta and the Songhor Lagoons have been designated as Ramsar sites.

Table 2.2-1. Vegetation Characteristics of the Volta Basin

Sub Basin	Vegetation Type
Black Volta	Tall grassland with fire resistant trees, scattered shrubs, patches of reserve forest (8%)
White Volta	Guinea savannah woodland (82%) interspersed by reserved forest (18%)
Lower Volta Northern	Mixed savannah woodland, Tall grassland with fine resistant trees
Central	Derived savannah interspersed with semi-deciduous rain forest
Southern	Semi-deciduous rain forest with patches of derived savannah
Daka	Savannah re-growth with scattered trees resulting from extensive cultivation
Oti	Savannah re-growth with scattered trees Semi-deciduous rain forest in southeastern corner

2.2.6 Protected Areas

In order to preserve some of the important ecosystems and biodiversity in the basin, the riparian countries designated a number of protected areas. Some of these are listed below.

Benin

The Pendjari National Park is located in the Volta Basin. This park has been included in the UNESCO Biosphere Reserve program due to its unique biodiversity and ecosystem.

Burkina Faso

The following is a list of fauna reserves in Burkina Faso's basin.

Table 2.2-2. List of Fauna Reserves of the Sudan Territory of the Basin

Designation	Classification	Area (ha)	Year of Creation	Location
Fauna reserve of Bontioli	Total	12,700	1957	Bougouriba Province
Fauna reserve of Nabéré	Partial	36,000	1957	Bougouriba Province
Fauna reserve of Bontioli	Partial	29,500	1957	Bougouriba Province

Designation	Classification	Area (ha)	Year of Creation	Location
TOTAL	**-**	**78,200**	**-**	**-**

Source : National monography on biodiversity.

Côte d'Ivoire
Within the Volta Basin, there are two classified forests where development is forbidden: Kolodio (61,000 hectares) and Nassian (19,640 hectares).

The Comoé National Park is also located in the basin with 1,150,000 hectares. Although it has only partially been studied, the following species have been identified under the framework of the pilot project GEPRENAF:

- 153 species of mammals
- 501 species of birds
- 35 species of amphibians
- 71 species of reptiles
- 60 species of fish

As in the majority of the protected areas, however, the true wealth of insects and other invertebrates remains unknown.

Ghana
The conservation areas in Table 2.2-3 (below) contain a wide variety of animals of global conservation significance. These include the elephant *Loxodonta africana,* many ungulates (duikers, antelopes, bushbucks, hartebeests, warthogs), carnivores (civets, leopards, cheetahs, hyenas, lions), primates (baboons, chimpanzees), reptiles (African python, monitor lizards, Nile crocodiles, hinged tortoise), the rare pygmy hippo *Choeropsis liberiensis*, the manatee *Trichehus senegalensis*, along with many birds, butterflies and other insects. Furthermore, two ungulates thought to be extinct, namely, the Korignum in northern Ghana, and Sigataunga, the only known ungulate inhabiting wetlands (recorded from Avu lagoon wetlands), have all been recently sighted in the basin. Finally, a wide variety of fin and shellfishes, macroinvertebrates, phytobenthos, and phytoplankton species, and wetland plants are found in Ghana's Volta Basin.

Table 2.2-3. Protected Areas in Ghana

Classification	Name	Area km^2	IUCN Management Category	Description
National Parks	Bui National Park	1821	II	Areas of national or international importance set aside by law to promote tourism, recreation, scientific research and education, and recreational uses
	Digya National Park	3478	II	
	Mole National Park	4840	II	
Strict Nature Reserve	Kogyae	386	Ia	Areas set aside for nature to take its own course without

Classification	Name	Area km^2	IUCN Management Category	Description
				human influence, permitting a first-hand study of primary ecosystem dynamics
Resource Reserve	Gbele	565	VI	Areas in which habitats are managed for sustainable production of wildlife products for cultural practices, tourism, and trophy hunting. Other compatible land uses may be allowed (previously known as game reserves)
	Kalakpa	325	VI	
Wildlife Sanctuary	Agumatsa	3	VI	Small areas set aside for the protection of rare and endangered species. These species may be introduced from other reserves when conditions are favorable
Ramsar Sites	Anlo-Keta Songhor	300 115	VII VII	Area set aside for the management of wetlands of international importance for waterfowl in which compatible land uses are allowed (The Ramsar sites in Ghana provide sanctuary to more than 80% of the migratory water birds stopping in the country)

Mali
Ramsar sites in Mali include Walado Débo, Lake Horo, and the Séri plain.

Togo
Togo has designated a number of protected areas in the basin. The table below outlines the amount of area protected by region.

Table 2.2-4. Distribution of Protected Areas in the Sub-Basin

Region	Number of Areas	Surfaces in ha	% of the entire surface area
Plateau	33	143,726	8.5
Central	13	248,662	18.7
Kara	22	109,777	9.3
Savannahs	9	265,981	31.4

Region	Number of Areas	Surfaces in ha	% of the entire surface area
Total	**77**	**768,146**	**14.2**

Source: DPCEF, Recueil des principaux textes relatifs à la protection de l'environnement, Edition 1993.

2.3 Biodiversity

The Volta Basin has a rich diversity of flora and fauna. Listed below are many of the species of global significance, including threatened and endangered species that are found in the Volta Basin. Although the data are lacking in some cases, the true wealth of the basin's biodiversity can nevertheless be seen.

2.3.1 Benin

a) *Flora*: The following flora can be found in the Oti (Pendjari) Basin.

Table 2.3-1. Plant Species in the Oti Basin

Species
Acacia seiberina (acacia)
Andansonia digitata (baobab)
Borassus aethiopum (rhônier)
Daniella oliveri (ledaniella)
Tamarindus indica (tamarinier)
Bombax coslatum (kapokier)
Parkia biglobosa (néré)
Diospyros mespikoformis
Khaya senegalensis
Cola laurifolia
Mitragyna inermis
Fereitia apodanthera

b) *Fauna:* From the north to the south, Benin has a variety of ecological conditions that support savannah and forest species. Elephants, Cobe de Buffon, panthers, buffalo, lions, monkeys, and a number of birds such as the gravelot, the brush garzette and the water hen can be found in the Oti Basin.

2.3.2 Burkina Faso

According to the national monograph on biological diversity of Burkina Faso (February, 1999), few systematic inventories have been undertaken, which leaves many gaps in data. The total number of indexed species is 3,992 macro-organisms. Summaries of the taxonomic inventory of the biological diversity in the White and Black Volta in Burkina Faso are presented below:

Table 2.3-2. Animal Species in White and Black Volta Basins in Burkina Faso

Kingdom	Components	Families	Genus	Species
Animalia	Insects	151	250	1,515
	Fauna (aquatic)	54	106	198
	Fauna (wild)	119	362	665
	Fauna (domestic)	11	14	16
Sub-Total		**335**	**732**	**2,394**

Table 2.3-3. Aquatic Fauna of Burkina Faso

Taxonomy	Family	Genus	Species
Fish	24	57	118
Batrachians	5	16	30
Mollusks	10	13	23
Shellfish	5	7	6
Zooplankton	10	13	16
Total	**54**	**106**	**193**

Source: Traore, A.C. and S.N. Zigani, 1996, Monographie

Table 2.3-4. Wild Terrestrial Fauna of Burkina Faso

Classification	Order	Family	Genus	Species
Mammals	11	33	77	128
Birds	20	76	246	477
Reptiles	4	10	39	60
Total	**35**	**119**	**362**	**665**

Source: Ouédraogo, L. and P. Kafando, 1996, Monographie

Table 2.3-5. Status of Threatened Species at the National Level in Burkina Faso

Category	Disappeared	In the Process of Disappearing	Threatened	Vulnerable	Total
Mammals	Oryx		Panthère Guépard Elephant	Damalisque Gazelle rufifron Gazelle dorcas Lycaon	8
Birds		Ostrich	Calao of abyssini	Crowned Crane	3
Reptiles			Crocodile Python		2
Fish				Protoptère (eel)	1
Woody Flora			*Acacia senegal* *Dalbergia*	*Adansonia digitata*	16

Category	Disappeared	In the Process of Disappearing	Threatened	Vulnerable	Total
			melanoxylon Pterocarpus lucens Vitex doniana Ximenia americana Dalbergia melanoxylon	*Bombax costatum Ceiba will pentandra Anogeissus leiocarpus Khaya senegalensis Prosopis africana Parkia biglobosa Vitellaria paradoxa*	

Source: Sp-conagese

Table 2.3-6. Plant Species in White and Black Volta Basins in Burkina Faso

Kingdom	Components	Families	Genus	Species
Plants	Higher mushrooms	8	13	28
	Algae	32	88	191
	Herbaceous flora of the humid zone	76	118	185
	Herbaceous flora of the land	87	333	627
	Woody flora	55	214	376
Total		**258**	**766**	**1,407**

Table 2.3-7. Threatened Plant Species in the Northern and Central Region of Burkina Faso

Overexploited and Rare Species in Urban Areas	Rare Species Threatened with Extinction	Vulnerable Food Species
Daniella oliveri	*Acacia erythrocalyx*	*Adansonia digitata*
Diospyros mespiliformis	*Annona senegalensis*	*Bombax costatum*
Entada africana	*Brachystelma simplex subsp. banforae*	*Vitellaria paradoxa subsp. Parkii*
Zanthoxylum xanthoxyloides	*Gossypium anomalium*	*Detarium microcarpum*
Sarcocephalus latifolius	*Guibourtia will copallifera*	*Lannea microcarpa*
Rauvolfia will vomitora	*Hibiscus gourmassia*	*Sclerocarya birrea.*
Securidaca longepedunculata	*Landolphia heudolotti*	*Spondias mombin*
Trichilia roka (= T. emetica)		*Saba senegalensis variété will glabriflora*
Vitex doniana		*Parkia biglobosa*

Overexploited and Rare Species in Urban Areas	Rare Species Threatened with Extinction	Vulnerable Food Species
Ximenia americana		*Tamarindus indica*

Source: Sp-conagese

2.3.3 Côte d'Ivoire

The Comoé National Park serves as habitat for a great number of threatened and endangered species, as is detailed in the table below.

Table 2.3-8. Rare and Endangered Species Inventoried in the National Park of Comoé in Côte d'Ivoire

IUCN Status	Family	Common Name
7 species with least risk of extinction but may be threatened soon	Cercopithecidae	Cercocèbe à collier blanc
	Cephalophinae	Céphalophe à bande dorsale noire Céphalophe bleu/C. de Maxwell Céphalophe noir Céphalophe à dos jaune
	Tragulidae	Chevrotain aquatique
	Tragelaphinae	Bongo
9 species with least risk of extinction, but depending on conservation measures	Hyaenidae	Hyène tachetée
	Alcelaphinae	Bubale
	Cephalophinae	Céphalophe à flancs roux
	Hippotraginae	Antilope rouanne
	Reduncinae	Cobe defassa Cobe de Buffon Rédunca
	Neotraginae	Ourébi
	Bovinae	Buffle
4 vulnerable species	Cecopithecidae	Diane
	Cercopithecidae	Colobe magistrat
	Felidae	Lion
	Crocodylidae	Crocodile de forêt
3 species threatened with extinction	Pongidae	Chimpanzé
	Canidae	Chien sauvage d'Afrique
	Elephantidae	Eléphant

Similar table not provided for flora

2.3.4 Ghana

Most flora and fauna species of international significance are found in the wet savannah, and wildlife and forest reserves within the basin. The Volta estuary and the Keta and Songhor

lagoons are important for their significant populations of waterfowl. These wetlands have been designated as Ramsar sites.

Ghana's coastal region also serves as habitat for significant species. Five species of marine turtles are found within the territorial waters of Ghana and use the beaches for nesting. These beaches are not protected, however, and in recent years have been threatened by erosion.

Table 2.3-9. Endemic Flora Species of the Volta Basin

Species	Status
Talbotiella genti	Endangered
Kyllinga echinatta	Not threatened
Aneilema setiferum	Not threatened
Gongronema obscurum	Insufficient data
Hilddergardia barteri	Insufficient data
Raphionacme vignei; var. pallidiciliatum	Not threatened
Rhinopterys angustifulia	Insufficient data

Table 2.3-10. Fauna of Global Conservation Significance within the Volta Basin in Ghana

Species		Animals In Protected Areas								Status
English Name	**Scientific Name**	**Mole N. P.**	**Dygya N. P.**	**Bui N. P.**	**Kogyae S. N. R.**	**Kalapa R. R.**	**Gbele R. R.**	**Agumatsa W. P.**	**Non - Protected**	**Endangered & Completely Protected**
i. Probocidea							✔		-	✔
1. Elephant	*Loxodonta africana*	✔	✔	-	✔					
ii. Primate										
2. Black & White colobus	*Colobus polykomos*	✔	✔		✔	✔			-	✔
3. Mona Monkey	*Cercopithecus mona*		✔		✔				✔	
4. Spot-nosed monkey	*Cercopithecus petaurista*		✔	✔	✔				✔	
5. Green monkey	*Cercopithecus aethips*	-	-		✔	✔			✔	
6. Patas monkey	*Erythrocebus patos*	✔	✔	✔	✔	✔			✔	
7. Baboon	*Papio anubis*	✔	✔	✔	✔		✔		✔	
iii. Caruivora										
8. Lion	*Panthera leo*	✔								
9. African civet	*Vivera civetta*	✔		✔					-	✔
10. Mongoose sp.	*Atilax poludionosus*								✔	
Spotted hyena	*Crocuta croauto*	✔								
iv. Arritiodctyla										
11. Hippopotamus	*Hippopotamus amphibius*		✔	✔			✔		-	✔
12. Pygmy hippopotamus	*Cheoropsis liberiusis*								-	✔
13. Hartebeest	*Alcelapluis burelophus*	✔	✔	✔			✔		✔	

Species		Animals In Protected Areas								Status
English Name	**Scientific Name**	**Mole N. P.**	**Dygya N. P.**	**Bui N. P.**	**Kogyae S. N. R.**	**Kalapa R. R.**	**Gbele R. R.**	**Agumatsa W. P.**	**Non - Protected**	**Endangered & Completely Protected**
14. Roan Antelope	*Hippotragus equinus*	✔	✔	✔			✔		✔	✔
15. Warthog	*Phacochoerus aethipicus*	✔	✔	✔			✔		✔	
16. Red river hog	*Potamochoerus porcus*		✔	✔			✔		✔	
17.Bushbuck	*Tragelaphus scriptus*	✔	✔	✔			✔		✔	
18. Buffalo	*Synceras caffer*	✔	✔	✔			✔		✔	
19. Reedbuck	*Redunca redunca*	✔							✔	
20. Waterbuck	*Kobus defessa*	✔	✔	✔					✔	
21. Kob	*Kobus kob*	✔	✔	✔					✔	
22. Oribi	*Ourebia ourebi*	✔	✔	✔					✔	
23. Red-flawced duiker	*Cephalophus rufitarus*	✔	✔	✔					✔	
24. Maxwell's Duiker	*Cephalophus maxwelli*								✔	
25 Gray Duiker	*Sylvicapra grirmmia*	✔	✔	✔					✔	
v. Crocodilia										
26. Nile Crocodile	*Crocodilus niloticus*	✔	✔	✔		✔	✔		-	✔
27. Long-snoufed crocodile	*Crocodilus cataphractus*	✔		✔					-	✔
28. Nile Monitor	*Veranus nitoticus*	✔		✔		✔	✔			
vi. Rodentia										
29. Ground squirrel	*Xerus sp.*		✔		✔				✔	
30. Tree squirrel	*Heliosciurus sp.*	✔	✔		✔				✔	

Species		Animals In Protected Areas								Status
English Name	**Scientific Name**	**Mole N. P.**	**Dygya N. P.**	**Bui N. P.**	**Kogyae S. N. R.**	**Kalapa R. R.**	**Gbele R. R.**	**Agumatsa W. P.**	**Non - Protected**	**Endangered & Completely Protected**
vii. Logomorpha										
31. Togo hare	*Lepus capensis*	✔	✔	✔		✔			✔	
viii. Ophidia										
32. African python	*Python sebae*	✔		✔		✔			✔	-
33. Royal python	*Python regia*			✔		✔			✔	-

2.3.5 Mali

Endemic plant species in the Basin of Mali (Samori and Seno) include the following: *Voandzea subterranean, Adansonia digitata, Acacia albida, Tamarindus indica, Parkia biglobosa, Vitellaria paradoxa, Ficus platiphylla, Kaya senegalensis, Pterocarpus erinaceus, Lanéa microcarpa, Combretum glutinosum, Prosopis africana, Bombax costatum, Sclerocarya birrea,* and *Sterculia setigera*.

Fauna are rare in the Seno sub-basin. In the Samori sub-basin, however, one can find guinea fowl, geese, and ducks. Mammals include gazelles, hyenas, jackals, and hares.

2.3.6 Togo

The basin in Togo offers a great variety of ecological conditions favorable for the development of biological diversity. The tables below give the state of the flora and fauna in the basin.

Table 2.3-11. Rare and Endangered Plant Species in the Oti Basin of Togo

Species	R	T	E
Acacia albida Del (Mimosaceae)	X		
Adenim obesiun (Forssk) (Roem. 1 Schult (Apocynaceae)	X		
Alafia multiflora (Stapf) Stapf (Apocynaceae)	X	X	
Amorphophallus accrensis (N.E.Br. Araceae)	X	X	
Balanites wilsoniana L. (Zygophilaceae)	X	X	
Begonia oxyloba Welw ex Hook (Begoniaceae)	X	X	
Canarium schweinfurthii Engl. (Myristicaceae)		X	
Cassipourea barteri N.E. Br. (Rhizophoraceae)	X		
Chaetacme aristata Planch. (Ulmaceae)	X		
Chrisobalanus atacorensis A. Chev. (Chrisobalanaceae)	X		
Chrysophyllum welwitschi Engl. (Sapotaceae)	X	X	
Cyathea camerooniana Hook (Cyatheaceae)		X	
Cyperrus mapanioides CBCI (cyperaceae)		X	
Dacryodes klaineaena (pierre) H.J. Lam (Burceraceae)	X		
Denettia tripetala bak F. (Menispermaceae)	X		
Diospyros ferrea (Willd) Bakh (Ebenaceae)	X	X	
Diospyros tricolor (schum. & Thonn.) Hier (Ebenaceae)	X	X	

R - Rare Plant Species
T - Threatened or Endangered
E - Extinct

The table shows that for the flora, approximately 10 species are endangered and 15 species are rare.

Table 2.3-12. Threatened and Endangered Animal Species in the Oti Basin of Togo

Species	Habitat	Present Status	Legal Status of IUCN / CITES
Mammals			
Gazella rufifrons	Keran	Probably	
Damaliscus korigum	Kéran	Extinct	
Hyemoschus aquaticus	Fazao	Probably	III
Neotragus pygmaerus		Extinct	
Tragelaphus O. derbianus		Endangered	I
Lycaon pictus	Fazao, Kéran	Vulnerable	
Acinoyx jubatu	R. Fazao	Vulnerable	
Panthera pardus	Fazao	Vulnerable	
Pan troglodytes	Fazao	Extinct	
Loxodonta africana	Fazao et 'Zone l'	Vulnerable	
Reptiles			
Crocodylus cataphractus	Mare de Fambuegou	Vulnerable	I
Osteolamus tereaspis	Marais du sud P. Fazao	Vulnerable	I
Python sebae	P. Fazao		
Python regius	Guinea Savannah, galleries	Vulnerable	II
	Forest galleries	Vulnerable	II
Birds			
Balearica pavonina	Humid Zones of Oti	Vulnerable	
Insects			
Graphium adamastor	Guinea forest and galleries	Threatened	IUCN. 2000
Graphium antheus	Guinea forest and galleries	Threatened	IUCN. 2000
Graphium leonidas	Guinea forest and galleries	Threatened	IUCN. 2000
Graphium agamedes	Forest	Threatened	IUCN. 2000
Graphiumangolanus	Forest	Threatened	IUCN. 2000
Grasphium fulleri	Forest	Threatened	IUCN. 2000
Graphiumillyris	Forest	Threatened	IUCN. 2000
Graphium latreillatus	Forest	Threatened	IUCN. 2000
Papilio antimachus	Guinea forest and galleries	Threatened	IUCN. 2000
Papilio bromius	Guinea forest and galleries	Threatened	IUCN. 2000
Papilio cynorta	Forest		IUCN. 2000

3.0 Socio-Economic and Development Setting

3.1 Population and Demographic Patterns

Population statistics for the Volta Basin are provided in Tables 3.1-1 and 3.1-2. The total basin population is expected to grow significantly from an estimated 18,600,000 in 2000 to approximately 33,900,000 in 2025. This is an expected increase of 80% in a twenty-five year period, which is very high. This high growth is due to the high average population growth rate in the basin of 2.54%.

Further, the figures indicate that the population in the basin is generally rural, ranging from 64 – 88%. This population distribution suggests that people in the basin, to a large extent, depend on the exploitation of natural resources for their livelihood. Such exploitation of natural resources may not be environmentally sustainable.

The geographic distribution of the population is quite variable, with the population density ranging from approximately 8 to 104 persons/km^2. This means that the pressure on land and water resources is sometimes concentrated in a particular area. For example, the population density of Ghana's Upper East Regions is 104 persons/km^2, while that of the Northern Region is only 26 persons/km^2. In Côte d'Ivoire, population density varies from 8 persons/km^2 in the north to 22 persons/km^2 in the south. The location of one of the largest parks in West Africa, the National Park of Comoé in Côte d'Ivoire, probably induces the low population density of that part of the basin. Further, valleys of the Black Volta where onchocerciasis, or river blindness, was prevalent have also not been heavily populated as people fled to escape the parasitic disease.

Table 3.1-1. Population Statistics in the Volta Basin

Country	1990	2000	2010	2020	2025	Growth Rate (%)	P/km^2 Density		
						2000	2000	Urban %	Rural %
Benin	382,328	476,775	596,000	746,000	820,000	2.27	43.4	36	64
Burkina Faso	7,014,156	8,874,148	11,227,366	14,204,605	15,997,351	2.38	41.53	22.6	77.4
Côte d'Ivoire	-	397,853	497,469	632,313	717,672	2.53	8 - 22	23	77
Ghana	5,198,000	6,674,376	8,570,068	11,004,185	11,696,054	2.5	26 - 104	16	84
Mali	380,000	625,000	880,000	1,140,000	1,260,000	2.78	45 - 75	12.2	87.8
Togo	1,189,900	1,594,446	2,153,719	2,891,457	3,385,266	2.80	66	30	70
Total	**14,474,276**	**18,642,598**	**23,924,622**	**30,618,560**	**33,876,343**				
Average						**2.54**	**48.49**	**23.30**	**76.70**

Table 3.1-2. Population Statistics (1999)

Country	Life Expectancy (Yrs)	Death Rate (%)	Literacy Rate (%)
Benin	53	14.40	15.20
Burkina Faso	54	14.00	26.00
Côte d'Ivoire	49	12.00	35.50
Ghana	53	9.10	20.30
Mali	47	13.40	8.70
Togo	56	13.00	20.30
Average	**52**	**12.65**	**21.45**

There have been some population migrations in the basin. In Ghana, the decline of the fishing industry in the Lower Volta following the establishment of the Volta Lake upstream has attracted people to move upstream to live near the lake for their livelihood. It is unfortunate that these settlements are often close to the banks of the lake, however. In Togo, some people in the basin (Savannas and Kara regions) who migrated to the southern regions of the country before 1990 are now returning due to socio-political unrest.

Mali has also seen migration into the "forest" of Samori, a sub-basin of the Volta. This movement is caused by the quest for new land for farming activities. Others moved into the basin after the drought of 1985. Another sub-basin in Mali, the Seno, has seen such a surge in population that there is no longer sufficient farmland to allow land to lie fallow, resulting in an impoverishment of the land. Additionally, there has been some migration out of the basin and into the urban areas where jobs are sought.

As noted above in Table 3.1-2, the literacy rate is in the range of 9 to 36% with a mean of approximately 21% for the entire basin. This low level of literacy can serve as an impediment to environmentally sustainable development. Additionally, there are significant disparities in the schooling and literacy rates for men and women. In Togo, for example, between 43 and 83% of women are illiterate, while the illiteracy rates for men are between 25 and 50%.

Life expectancy in the basin is fairly low, varying between 47 and 56 years with an average of 52 (Table 3.1-2). The infant mortality rate in the basin is high, estimated in 1993 to be between 68.3 and 113.7 per 1000 births in Ghana. A major factor in the short life expectancy of the population of the Volta Basin is inadequate access to health care. Access to public health care in the Volta Basin of Ghana is poor and significantly below the national average of 37.2% (PIP, 1990). The average of access to public health care in the basin is only approximately 15%. In the southern rural part of the basin in Côte d'Ivoire, the doctor – patient ratio is 1:18,684, while in the north the ratio is 1:24,561. These figures are similar to those for other parts of the basin.

The tropical environment of the Volta River Basin is conducive to the growth of a wide variety of deadly microbes and their hosts. All major water-related diseases like Bilharzias, Onchocerciasis, Guinea worm, malaria, filariasis, etc., are prevalent in the Volta Basin.

3.2 Regional Economic Characteristics

The riparian countries of the Volta River Basin are some of the poorest in the world and have underdeveloped economies. According to the World Development Report 2000/2001, all of the Volta River Basin countries are considered to be in the low income category (GNP per capita of $755 or less). Per capita GNP and economic growth rates for the riparian countries are shown in Table 3.2-1.

Table 3.2-1. Gross National Product and Average Growth Rate for the Riparian Countries

Country	GNP/Capita ($) (1999)	Average Annual Growth Rate (%) (1998 - 1999)
Benin	380	2.2
Burkina Faso	240	2.7
Côte d'Ivoire	710	1.1
Ghana	390	2.1
Mali	190	2.7
Togo	320	-0.3

(World Development Report 2000/2001, 2001)

Côte d'Ivoire has the highest GNP in the region with $710 per capita, while Mali is ranked lowest with only $190. The average GNP/capita is $372, making this one of the world's poorest regions. Although the figures quoted in the table are national values, the condition in the basin is not better than the remainder of the countries. The average annual growth rates in the range of –0.3 to 2.7% of GNP/capita also show low performance of the economies of the region.

Additionally, the region is saddled with a heavy burden of external debt as indicated in Table 3.2-2.

Table 3.2-2. External Debt of the Riparian Countries (1998)

Country	Millions of Dollars	% of GNP
Benin	1,647	46
Burkina Faso	1,399	32
Côte d'Ivoire	14,852	122
Ghana	6,884	55
Mali	3,202	84
Togo	1,448	68
Average	4,905	70

(World Development Report 2000/2001, 2001)

The debt burden ranges from 32% to as high as 122% of the GNP. The average, as well as the median, debt burden for the sub-region is about 70% of the GNP. This poor economic situation can potentially inhibit any meaningful sound environmental development with respect to the exploitation of natural resources for socio-economic development.

Economic activities in the basin are quite similar in all of the countries: crop production, livestock breeding, fishing, lumber, agro-industry, transportation, and tourism. These activities can be grouped under agriculture, industry, manufacturing, and services.

Agriculture includes crop and livestock production, fisheries, and forestry, while industry involves mining and quarrying, electricity supply, and construction; services include transport, storage, communication, wholesale and retail trade, restaurants and hotels, government services, etc. The economic outputs of these activities are shown in Table 3.2-3.

Table 3.2-3. Structure of Economic Output at the National Level

	Gross Domestic Product Millions of $		Value added as % of GDP							
			Agriculture		Industry		Manufacturing		Services	
Country	1990	1999	1990	1999	1990	1999	1990	1999	1990	1999
Benin	1,845	2,402	36	38	13	14	8	8	51	48
Burkina Faso	2,765	2,643	32	32	22	27	16	21	45	41
Côte d'Ivoire	10,796	11,223	32	24	23	24	21	20	44	52
Ghana	5,886	7,606	45	36	17	25	10	9	38	39
Mali	2,421	2,714	46	47	16	17	9	4	39	37
Togo	1,628	1,506	34	43	23	21	10	9	44	36
	-	-	37.8	36.7	19.0	21.3	12.3	11.8	43.5	42.2

(World Development Report 2000/2001)

The table shows economic outputs for the countries as a percentage of GDP in 1990 and 1999. The activity output is shown as a percentage of the GDP. From the table, it can be observed that services and agriculture are most prominent in the sub-region, averaging 42% and 37% of GDP, respectively (1999). Industry follows in third place. The services sector averages 19% and 21% of GDP in 1990 and 1999, respectively. The services sector is dominant in the urban areas, whereas agriculture dominates in the rural areas. It is worth noting that the type or intensity of activities did not change significantly over the 1990 to 1999 period.

3.2.1 Agriculture

Accurate and specific data are not easily available on the economic output of the basin as these data are embedded in the national figures. It may be surmised, however, that agricultural production in the basin, which has a higher rural population than the national averages, will not be less than 40% of the entire economic output of the basin.

To demonstrate the importance of agriculture in the basin, some information from the national reports is presented.

In Ghana, Table 3.2-4 shows the production levels of selected staple crops by regions in the basin.

Table 3.2-4. Production Levels of Selected Crops by Regions in the Volta Basin in Ghana (Tonnes)

Region	Yam	% of National Total	Cassava	% of National Total	Maize	% of National Total	Rice	% of National Total
Upper East	-		-		16,280	1.6	65,379	26.3
Upper West	263,416	7.8	-		56,725	5.6	9,281	3.7
Northern	518,000	15.4	68,500	0.8	81,800	8.1	71,360	28.7
Volta	112,265	3.3	424,350	5.2	48,980	4.8	14,530	5.8
Eastern*	529,014	15.7	767460	9.5	97,014	9.6	2,250	0.9
Ashanti*	186,248	5.5	373,674	4.6	12,530	1.2	706	0.3
Brong Ahafo*	1,000,337	29.7	854,659	10.5	91,985	9.1	32	0.0
Greater* Accra	-		38,603	0.5	2,269	0.2	8,469	3.4
Total in Basin	**2,609,280**	**77.6**	**2,527,246**	**31.2**	**407,583**	**40.2**	**172,007**	**69.1**
National Total	**3,363,000**		**8,107,000**		**1,013,000**		**249,000**	

Source: SRID, MOFA, 2000

*Figures are totals for Districts that fall within the Volta Basin, whether wholly or partially.

From the table, it can be observed that the basin in Ghana produces 78% of the total national output of yams, 31% of cassava, 40% of maize, and 69% of rice.

Table 3.2-5 on the following page shows the statistics of cereal production in two districts of the Volta Basin of Mali. These regions are considered to be the granary of the Mopti region and 85% of the local population is engaged in agricultural production.

Table 3.2-5. Cereal Production in the Mopti Region of Mali (Tonnes)

KORO											
Cereals/Years	**1990-1991**	**1991-1992**	**1992-1993**	**1993-1994**	**1994-1995**	**1995-1996**	**1996-1997**	**1997-1998**	**1998-1999**	**1999-2000**	**2000-2001**
Millet	67930	64770	66440	67800	67800	66735	65500	68225	68400	68700	69000
Sorghum		3500	3950	3660	3760	4400	4400	4275	4300	4600	4650
Paddy rice	320	270	270	360	330	380	350				4150
Niébé	1545	3245	3640	980			1950	1700	2320	2370	2426
Fonio	5020	4190	4264	4990	5350	4530	3380	4030	1940	1940	2000
Groundnuts	1620	5470	5750	5520		5985	5670	6150	5975	6030	6324
BANKASS											
Cereals/Years	**1990-1991**	**1991-1992**	**1992-1993**	**1993-1994**	**1994-1995**	**1995-1996**	**1996-1997**	**1997-1998**	**1998-1999**	**1999-2000**	**2000-2001**
Millet	48700	42600	44300	45800	45900	45600	46900	46800	47500	48000	48945
Sorghum		6300	8100	8300	8500	9230	9900	9900	9800	9800	10500
Paddy rice	170	275	1050	1600	1900	3250	3800	3900	5600	5400	4150
Niébé	2490	4200	4000	1600	1450	1360	1500	1700	1800	1875	2050
Fonio	4900	4650	4850	4900	4825	4330	4100	3950	3500	3500	3335
Groundnuts	1760	4750	4800	5800	5800	4900	5650	5100	5850	5750	5880

The production of crops in Côte d'Ivoire is presented in Table 3.2-6.

Table 3.2-6. Crop Production in Côte d'Ivoire (1996)

Produce	Quantity (Tonnes)
Cocoa	816
Coffee	1,099
Cotton	1,511
Cashew nut	12,482
"Roucou"	1,951
Yams	225,703
Maize	14,500
Cassava	42,695
Rice	2,341
Groundnut	4,330

Irrigated land as a percentage of cropland for 1995–97 for Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, and Togo are 0.8, 0.7, 1.0, 0.2, 2.1, and 0.3, respectively (World Development Report 2000/2001, 2001). Thus, crop production under irrigation is negligible in the sub-region as most arable farming is predominantly rainfed. With current climate change, rainfall is believed to be becoming more variable and unreliable. Extensive crop farming coupled with variable and unreliable rainfall patterns in a region where poverty is predominant has far-reaching implications on the environment and food security.

3.2.2 Livestock

The rich savannah grassland provides good fodder for livestock production. Animal husbandry data for some of the riparian countries are shown in the following tables.

Table 3.2-7. Livestock Production in Côte d'Ivoire

Type	Cattle	Sheep	Goats	Pig	Poultry
Number	117,173	253,646	205,199	5,612	1,504,614

Table 3.2-8. Projected Livestock Production in Togo (1999-2005)

Annual Production	1999	2001	2003	2005
Cattle	299,970	318,239	337,619	340,136
Sheep / Goats	5,158,621	5,472,781	5,806,073	7,292,244
Pigs	408,755	433,648	460,057	464,762
Poultry	1,216,278	12,903,494	13,689,317	16,612,295

Source: Programme de Développement de l'Elevage au Togo/September 1996

Table 3.2-9. Projected Livestock Production in Togo (2010-2025)

Annual Production	2010	2015	2020	2025
Cattle	346,509	353,003	359,684	366,365
Sheep / Goats	12,891,380	17,447,658	28,869,040	40,290,422
Pigs	595,997	639,269	819,759	1,000,249
Poultry	26,949,411	37,188,484	56,985,036	76,781,587

Table 3.2-10. Population of Major Livestock by Region Based on 1996 Livestock Census in Ghana

Region	Cattle		Sheep		Goats		Pigs		Poultry	
	No.	%.	No.	%	No.	%	No.	%	No.	%.
Upper East	214,717	17.2	211,670	9.1	192,689	7.6	36,767	10.4	811,925	5.6
Upper West	284,162	22.8	231,819	10.0	542,316	21.4	68,886	19.4	1,005,733	6.9
Northern	429,460	34.4	339,406	14.6	365,314	14.4	45,727	12.9	1,559,865	10.7
Volta	112,926	9.1	369,544	15.9	432,025	17.1	47,792	13.5	970,845	6.7
Brong Ahafo	50,009	4.0	226,074	9.7	233,388	9.2	36,756	10.4	797,146	5.5
Ashanti	21,668	1.7	240,073	10.4	184,939	7.3	19,019	5.4	2,286,841	15.7
Eastern	53,918	4.3	226,083	9.8	197,654	7.8	18,972	5.3	826,940	5.7
Greater Accra	68,098	5.5	114,781	5.0	104,145	4.1	20,657	5.8	5,341,120	36.6
Western	4,796	0.4	230,379	9.9	153,081	6.0	43,641	12.3	304,110	2.1
Central	8,107	0.6	128,909	5.6	127,159	5.0	16,461	4.6	684,778	4.7
National Total	1,247,861	100	2,418,738	100	2,632,710	100	354,678	100	14,589,303	100

Source: Animal Production Department, MOFA, 2001

Table 3.2-11. Estimates of National Livestock Population in Ghana (1995 – 2000)

Year	Cattle	Sheep	Goats	Pigs	Poultry
1995	1,122,730	2,010,147	2,155,938	365,339	13,082,252
1996	1,247,861	2,418,738	2,532,710	354,678	14,558,970
1997	1,203,132	2,330,386	2,458,307	339,808	15,878,568
1998	1,209,317	2,366,407	2,523,004	325,884	17,281,997
1999	1,215,534	2,402,985	2,589,404	312,531	18,809,469
2000	1,221,783	2,440,128	2,657,551	299,725	20,472,222

Source: Animal Production Department, MOFA, 2001

Table 3.2-12. Population of Major Livestock in the Volta Basin in Ghana

Livestock	Population	% of National Total
Cattle	1,111,707	89.1
Sheep	1,672,395	69.1
Goats	1,854,749	70.5
Pigs	231,760	65.3
Poultry	5,479,352	37.5

Four regions, including the Upper-East, Upper-West, Northern and Volta, which fall exclusively in the basin, account for 83.5%, 57.7%, 64.1%, and 68.8% of cattle, sheep, goats, and pigs, respectively.

3.2.3 Fisheries

Fish production is also an important para-agricultural activity in the basin. In the Oti River in Benin, fish are abundant. Downstream in Togo, fishing is also found to be a secondary activity of the population.

During the drought of the 1970s, fishing gained importance as an economic activity and as a source of food in Burkina Faso. Fishing is done in rivers (Mouhoun, Oti, Kompienga, Comoé, Léraba, Béli, Faga, Garoual, Sirba, and Tapoa) and in reservoirs (Kompienga, Bagré, Sourou, Moussodougou, Zega, Loumbila, and Kanazoé). Families of fish that are exploited include Cichlidae, Centropomidae, Mochokidae, Clariidae, Bagridae, Clatoteidae, Characidae, Mormyridae, and Osteoglossidae. Although this area has not been studied adequately, it is estimated that between 8,000 and 8,500 tons of fish are caught annually at a national level, and that this amount constitutes roughly 60-70% of biological capacity. The fish resources are being modified and threatened by overexploitation in certain areas due to the degradation of waterways, however.

Fish farming and fishing in Côte d'Ivoire experienced a takeoff in 1978 with a fishery development project. A provisioning center of 8 ponds with a capacity of 60,000 alevins per year and 52 fish farming ponds were established. The fish farming activity has strongly regressed since 1993, however, largely due to inadequate water resources and the slowdown in farming.

In Ghana, the Volta Lake created by the Akosombo Dam produced about 87,500 metric tons of fish in 2000. It is stated that the Volta Lake produces about 98% of the inland fresh water fish in Ghana (Braimah, 2001). The increases in fish landings from the Volta Lake in the last half-decade (Table 3.2-13) are the result of deployment of active gear, such as the winch net, with unapproved mesh sizes in the lake. This situation is extremely dangerous for a fishery that is already experiencing over-exploitation. If the current practices are not regulated, the Volta Lake fishery could crash in the near future.

Table 3.2-13. Annual Fish Production in Ghana

Source	1996		1997		1998		1999		2000	
	No.	%	No.	%	No.	%	No.	%	No.	%
Marine	378,000	84	377,600	80	336,700	74.3	384,700	83.7	421,320	82.8
Inland	74,000	16	94,400	20	116,200	25.7	75,000	16.3	87,500	17.2
Total	452,000		472,000		452,900		459,700		508,820	

Source: SRID, MOFA, 2001

Prior to the construction of the dam on the Mouhoun in Burkina Faso, fishing in Mali was done using rudimentary equipment and the activity did not provide a significant source of income. When the waters rose, however, several villages moved to the edge of the river and fishing became a more important activity. The industry has since moved from subsistence to commercial.

3.2.4 Forestry

Forests in the basin are cut to provide firewood and charcoal for local populations. Additionally, forests are developed to provide lumber. For example, the forests in the Togo section of the basin provide more than half of the country's production of sawlog (Togo National Report). Forests in the region have been severely overexploited, however, and are threatened.

3.2.5 Industry

While industrial development is not extensive in the region, some industries, including hydropower generation, are important. In Ghana, production of hydropower in the basin for distribution among the neighboring riparian countries is a critical economic activity. The installed capacity of hydroelectric plants at Akosombo and Kpong amounts to 1072 MW. Balgré and Kompienga dams in Burkina Faso generate hydropower with an installed capacity of 14.4 MW and 12.3 MW. In 1996, they produced 72.5 GWh of electrical energy. Some other hydropower schemes are planned in other parts of the basin.

In Burkina Faso, a number of industries are located in the basin that both use large quantities of water and emit waste into waterways. These include agro-processing (breweries, slaughter-houses, and soap factories), chemical (pesticides), and textiles (tanning and sewing).

Industries in the basin in Ghana, with the exception of a few large textile factories located near the dams, are generally small-scale. They typically employ between two and six workers and use local raw materials. Industries in the following categories are scattered throughout the basin in Ghana.

Table 3.2-14. Industry in Ghana

Category	Specific Activities
Agro processing	Cassava processing
	Sheabutter extraction
	Grain milling
	Groundnut oil extraction

Category	Specific Activities
	Pito brewing
	Fish smoking
	Liquor distillery
	Tobacco curing
	Bakery
Wood Based	Wood carving
	Charcoal burning
	Carpentry and joinery
	Charcoal burning
	Canoe building
Leather works	Shoemaking
	Leather tanning
Metal	Blacksmithing
	Vehicle mechanic
Textile	Mat weaving
	Straw hat & basket weaving
	Tailoring, Dressmaking

3.2.6 Mining

The Volta River Basin is rich in mining resources, such as phosphate, uranium, gold, and iron, but few resources have yet been developed. In Togo, only iron has been exploited and it is generally done artisanally. Small-scale surface mining for gold has developed recently in the Upper East section of the basin in Ghana, with potential environmental effects. Gold is extracted artisanally in several areas of Burkina Faso, including Kaya, Bittou, and Yako. Additionally, several national and foreign mining companies prospect or exploit licenses that were conceded to them in the basin.

3.2.7 Tourism

While there are many natural and cultural attractions in the Volta River Basin, tourism remains underdeveloped. An area that attracts visitors, however, includes the Pendjari National Park of Benin, which receives between 2,000 and 2,500 visitors annually. Côte d'Ivoire also has a number of points of interest, which are primarily located in the northeast. These include the Comoé National Park (the largest of West Africa), although the current condition of the trails and facilities in the park are not conducive to tourists. Additionally, Togo has a number of areas in the basin visited by tourists.

3.3 Analysis of Use of Land and Water Resources and Future Trends

3.3.1 Regional Land and Water Resource Availability

3.3.1.1 Water Resources

Water is available for use from three sources: precipitation, streamflow, and groundwater.

The distribution of precipitation follows the climatic patterns as described in section 2.1.5. Some parts of the basin have a single annual peak of rainfall of short duration, whereas other areas have double maxima. Annual rainfall varies from about 1600 mm to 400 mm across the basin. Rainfall distribution is not uniform throughout the year and, instead, is strongly seasonal. Some of the drier areas in the northern section of the basin receive rainfall during three months of the year, while the other nine months are dry.

Streamflow, or run-off, naturally relates to the magnitudes of rainfall and evapo-transpiration in the locality or the sub-catchment. Rainfall in the upper reaches or higher latitudes of the catchment are low and thus run-off is also limited.

Water resources in general diminish from the southern to the northern part of the basin.

3.3.1.2 Land Resources

As agriculture and animal husbandry are the primary economic activities in the basin, land resources are critical to the basin inhabitants. The resources currently meet these needs, but the growing population pressure that will require additional land, combined with the anthropogenic and climatic threats to land resources detailed in Section 5.1, suggest that this might not always be the case.

Land ownership in the region remains primarily traditional, meaning that lands are often owned or managed by local elders or leaders. As a result, the major institutions involved in land administration are the traditional leaders in some countries. Thus, a significant problem associated with land resources is the institutional and legal framework governing the release of land for use.

Some lands are also preserved as natural habitats for flora and fauna and are unavailable for use; however, illegal exploitation of the land resources has reduced their value.

Additionally, some lands are already degraded to the point of non-productivity. For example, in the Lower Volta Basin, the establishment of the Akosombo Dam has rendered some of the soils in the area more acidic. As a result, the yields from farms in the region have been reduced considerably. The potential of such lands has been reduced and will require remedial measures.

3.3.2 Regional Land and Water Resource Demand for the Present and Future

3.3.2.1 Water Resources

Water resources are needed for various purposes, such as for the production of food, industry and energy production, domestic water supply, sanitation, transportation, as well as for the maintenance of the ecosystem.

Quantities of water needed for domestic and industrial activities, irrigation, and livestock production are referred to as the water demand for the sector. These uses are, in general, indicated as consumptive uses since they are not available for other uses.

Water for hydropower generation is, on the other hand, non-consumptive since the water passing through the turbines can be used for other purposes. However, non-consumptive use such as hydropower generation also has some losses of water through increased evaporation from reservoirs. Both consumptive and non-consumptive uses are relevant for integrated management of the basin.

The basin demand for water is an aggregation of the demands from the riparian countries over a period of time. The country demand, in turn, is dependent on the types of economic activities undertaken, as well as the level of the country's development as more advanced economies will demand more water than less advanced ones. Population is also a factor in determining the quantity of water needed for domestic use.

Projections for water demand are thus based on growth of population and the activities envisaged to be carried out under the country's development plans. The projected water demand outlined in this section was synthesized from country reports.

Table 3.3-1 shows the water demand for domestic and industrial activities. These are projected to increase due to the rapid population increase and envisaged industrial expansion, both of which will require an increased use of water. The domestic/industrial water demand for Benin was, however, very high and may be due to planned economic development activities.

Table 3.3-2 presents water demand data for irrigation in the basin. In Ghana and Benin, the increases expected are quite high. The percentage increases of year 2020 demand over year 2000 are 538% and 706% for Ghana and Benin, respectively. The high projections of water demand for irrigation in the basin stem from the fact that rain-fed agriculture is becoming more precarious and less reliable under climate change and the ensuing variable precipitation. Further, the need to produce adequate food to feed the rising populations is a major concern of the countries in the sub-region.

Table 3.3-3 presents the information on water demand for livestock production. It is observed again that the demand for water needed for livestock will increase by several times by the year 2025 to meet the protein requirements of the basin population and for export.

The information provided in Table 3.3-4 for the total water demand shows drastic increases of 62% to 1221% in year 2020 over year 2000 water demands. The sharp increases are, however, largely driven by the high irrigation water demand projected for the future.

While significantly higher demands have been projected for the near future, current demands are not now being met in most countries. For example, the water resource supply for the Volta Basin in Ghana for 2000 was 245 x $10^6 m^3$ (WARM, 1998). This implies that for a demand of about 729 x $10^6 m^3$, only 34% was met. The problem of not being able to meet the consumptive water demand depends, to a large extent, upon inadequate infrastructure of water supply systems. This means that there are not sufficient financial resources to store, treat, and distribute water.

Seasonal variations also hinder the ability to supply needed water resources. For example, in the upper reaches of the catchment, such as in Mali and some sections of Burkina Faso, river flows are not year round and some wells and groundwater boreholes go dry during certain months. Thus, water-resources availability becomes a problem.

Hydropower generation is an important economic activity in the basin, especially for Ghana. The power is sold among some of the riparian countries: Togo, Benin, and Burkina Faso. In Ghana, Akosombo and Kpong generate hydropower and the combined capacity of the two schemes is 1060 MW. Water demand for the two for generation is approximately 37.8 billion m^3.

Table 3.3-1. Domestic/Industrial Water Demand of the Volta River Basin (x $10^6 m^3$)

Country	1990	2000	2010	2020	2025
Benin		56	196	336	448
Burkina Faso	67	85	106	132	149
Côte d'Ivoire	-	4	5	12	14
Ghana	82	138	192	272	284
Mali	5	9	13	16	18
Togo	51	68	92	123	145

Table 3.3-2. Irrigation Water Demand of the Volta River Basin (x $10^6 m^3$)

Country	1990	2000	2010	2020	2025
Benin		152	548	1,225	1,600
Burkina Faso	43	203	384	554	639
Côte d'Ivoire	-	19	57	166	276
Ghana	75	565	1,871	3,605	3,733
Mali	126	180	219	291	311
Togo	43	50	91	133	171

Table 3.3-3. Water Demand for Livestock of the Volta River Basin (x $10^6 m^3$)

Country	1990	2000	2010	2020	2025
Benin		40	94	133	175
Burkina Faso	37	46	61	78	88
Côte d'Ivoire	-	1	2	3	3
Ghana	18	26	41	63	67
Mali	4	34	74	123	142
Togo	15	19	22	30	36

Table 3.3-4. Total Consumptive Water Demand of the Volta River Basin (x $10^6 m^3$)

Country	1990	2000	2010	2020	2025	% Increase 2020/2000
Benin	-	249	838	1,694	2,223	583
Burkina Faso	147	335	550	764	876	128
Côte d'Ivoire	-	24	64	181	293	1,221
Ghana	175	729	2,104	3,940	4,084	424
Mali	136	223	306	430	471	93
Togo	109	137	205	286	351	62

3.3.2.2 Land Resources

Information on demand for land resources is inadequate in the basin. Statistics of land use were given, for example, in Togo and out of a basin area of 2,670,000 ha only 428,000 (16%) were put under cultivation in 1995, while an area of 528,420 ha (19%) were under forest reserve. Fertility of the soils was not discussed, but this could be a limiting factor due to the expansion of agricultural lands. For the Volta Basin in Burkina Faso, 3,905,500 ha, representing 22.5% of the basin area is under cultivation. It was indicated that land availability in that area for farming is becoming limited but is not yet in a crisis situation. Throughout the basin, the loss of soil fertility due to erosion, over-use, over-use of manure, and uncontrolled bushfires were identified as problematic issues.

Farming practices could determine the size of land needed for future activities. With the increase in population, the available data and information suggest that demand for land for farming will increase with the view to achieving food self-sufficiency in the basin, as well as increasing food exports. Population pressure has not only expanded pasturage, but also reduced its quality due to reduced crop rotation and not allowing sufficient time for croplands to lie fallow to regenerate essential nutrients.

4.0 Legal and Regulatory Setting

Institutional structures and legal frameworks have been established to some degree in the riparian countries for environmental management, as documented in the various country reports. A summary of the various national institutional structures and legal frameworks is presented in tables below. The institutions charged with transboundary water resources issues are then discussed in greater detail. A short summary of legal and institutional constraints follows.

4.1 Benin

Benin has developed a number of laws and institutions to address the environmental impacts of activities in the country, which are outlined in the following table.

Table 4.1-1. Ministries and Departments for Managing Land and Water Resources in Benin

Ministry	Departments	Responsibilities
Ministry of Environment, Settlements, and Urban Development	Environment, Sanitation, and Urban Roads, Administration of Territories	Management of the Environment
Ministry of Agriculture, Livestock, and Fishing	Rural Development, Forest and Natural Resources, Agriculture, Fishing, Livestock	Management of Natural Resources, Water, and Soils
Ministry of Mines, Energy, and Hydraulics	Mining, Beninois Society of Electricity and Water, Hydraulics	Management of Mineral Resources, Management and Distribution of Water Resources at the National Level
Ministry of State in Charge of Coordination of Government Act, Forecasting, and Development	-	Identification of projects and programmes that will have positive impacts on the environment. Follow-up of projects and programmes and their actual impacts on the land, and in particular the environment
Ministry of Interior and Security and Decentralization	Department of Territorial Administration; Department of Local Community; National Commission of State Affairs; Department of Prevention and Soil Protection	Environmental issues

Ministry	Departments	Responsibilities
Ministry of Law and Justice and Human Rights	Department of Law and Codification	Support of the legal framework
Ministry of Finance and Economy	-	Development of policies for improving the environment, e.g., tax incentives
Ministry of Public Health	Department of Hygiene and Sanitation	Implementation of national policies in matters of hygiene and health
Ministry of Higher Education and Scientific Research	National University of Benin; Committee of Man and Biosphere; Beninois National Commission of UNESCO; Beninois Center of Scientific Research and Technique	Concern about environmental policies

Apart from the Ministries having some roles in managing water and land resources, the Beninois government has put in place measures that give roles to the local communities concerning sanitation, public health, and roads.

Several legislative texts have been passed for rational management of the natural resources of the country. Some of these include:

1. Decree No. 82-435; December 30, 1982 against bushfires and setting fires to plantations.
2. The Law No. 87-016; Water Code.
3. The Law No. 98-030; February 12, 1999 on legal framework for the environment of the republic of Benin.

4.2 Burkina Faso

The overall vision of the country's framework for managing natural resources, expressed in the document "Policies and Strategies in Water Matters" adopted by the Burkinabe government in 1998, is of sustainable human development. This means providing economic security, health, food security, and a sound environment, among other things. The following laws are in existence for the management of the environment and land resources:

1. Act No. 005/97/ADP
2. Act No. 0014/96/ADP of 23 May 1996

Table 4.2-1 gives the responsibilities of the various government ministries and departments associated with the management of land and water resources in Burkina Faso.

Table 4.2-1. Departments for Managing Land and Water Resources in Burkina Faso

Department	Responsibilities
Foreign Affairs	To implement framework of agreements of international cooperation
Administration of Territories/Lands	Land administration
Energy and Mines	Production of hydropower and utilization of mineral resources
Tertiary and Secondary Education and Scientific Research	Education and training
Public Works, Settlements and Urban Development	Road infrastructure and urban sanitation
Agriculture	Enhance irrigation development
Animal Resources	Management of pastoral zones
Health	Public Health
Transport and Tourism	Collection of climatological data
Social Action and the Family	Management of risk linked to water
Authorities for managing valleys	AMVS, MOB

Other actors associated with the land and water resources management include NGOs, the private sector, and development partners.

Some difficulties encountered in institutional management include sectoral management of natural resources and inadequate management of human and financial resources.

4.3 Côte d'Ivoire

In Côte d'Ivoire, numerous institutions are charged with the responsibility of managing and using water resources. This situation has led to fragmentation and dispersion of functions among the institutions.

The functions of main actors in water resources are divided into two main groups: managers and users. The law that created this division was Law No. 98 – 755. There are two codes regulating, protecting, and guiding the use of water: environment and water codes.

The ministry with overall responsibility for managing water resources is the Ministry of Water and Forests. It is the authority in charge of policies for managing water resources. Additional ministries include:

Table 4.3-1. Ministries and Their Responsibilities in Côte d'Ivoire

Ministry	Responsibilities
Ministry of Water and Forests	Management of water resources
Ministry of Economic Infrastructure	Provision of potable water
Ministry of Agriculture and Animal	Agropastoral and fishing

Ministry	Responsibilities
Resources	
Ministry of Mines and Energy	Generation of hydroelectricity
Ministry of Transport	River and maritime transport
Ministry of Construction and Urban Development	Sanitation
Ministry of Environment and Life	Protection of water
Ministry of Economy and Finances	Financing of water projects
Ministry of Planning and Development	Scheduling of projects
Ministry of Public Health	Protection against diseases associated with water
Ministry of Industry	Industry
Ministry of Tourism	Tourism
Ministry of Interior and Decentralisation	

Ministries in charge of management and use of land resources are given in Table 4.3-2.

Table 4.3-2. Ministries for the Management and Use of Land Resources in Côte d'Ivoire

Ministry	Responsibilities
Ministries of Water and Forests	Protection of soils and fight against desertification
Ministry of Environment and Life	Protection of Ecosystems
Ministry of Construction and Urban Development	Management of urban areas
Ministry of Agriculture and Animal Resources	Agricultural development and management of rural areas
Ministry of Mines and Energy	Mineral exploitation

A legal framework that came into force in December 1998, the Rural Land Code, allows for the registration and security of rural lands.

4.4 Ghana

Acts establishing new institutions and strengthening existing ones for managing water resources in Ghana, and in particular the Volta Basin, are as follows:

- Act 46 of 1961 (Volta River Development Act) sets up the Volta River Authority (VRA). The VRA has the mandate to plan, execute and manage development of the Volta River. The primary function of the VRA is to generate power for the country's industrialization.
- Act 490 of 1994 establishes the Environmental Protection Agency.
- Act 522 of 1996 establishes the Water Resources Commission.
- Act 462 of 1993 establishes the District Assemblies.

Land ownership is basically traditional, except in areas demarcated and controlled by government agencies, such as the Volta River Authority and Departments of Forestry and Wildlife. Families and individuals have access to and control of resources through birth.

Government departments and agencies charged with responsibilities of usage or management of water resources are presented in Table 4.4-1.

Table 4.4-1. Ministries and Departments Responsible for Water Resources Development and Utilization in Ghana

Ministry	Department/Institutions	Responsibilities
Ministry of Works and Housing (MWH)	Water Resources * Commission	Planning and regulation of the development and use of freshwater resources in Ghana
Ministry of Environment and Science (MES)	Environmental Protection Agency (EPA) *	Management of the country's environment, collaborating with relevant state institutions and international bodies in ensuring sustainable development of the country's natural resources
Ministry of Lands and Forestry	Forestry Commission *	Control and planning of forestry resources
Ministry of Mines	Mineral Commission*	Granting of mining rights
	Public Utilities Regulatory Commission *	Regulate the supply, transmission, and distribution of treated water
Ministry of Energy (ME)	Volta River Authority (VRA) **	Plan, execute and manage the development of the Volta River for hydropower generation
Ministry of Food and Agriculture	Irrigation Development Authority **	Development of irrigation in the country
Ministry of Works and Housing	Ghana Water Company Ltd. **	Provision of potable water for urban settlement
Ministry of Works and Housing	Community Water and Sanitation **	Provision of potable water for rural communities
Ministry of Roads and Transport	Meteorological Services Department ***	Assessment of Atmospheric Water Resources
Ministry of Works and Housing	Hydrological Services Division ***	Collection of hydrological data
Ministry of Environment	Water Research Institute	Assessment of surface and

Ministry	Department/Institutions	Responsibilities
and Science	of CSIR ***	groundwater resources in quantity and quality.

* Organization involved primarily in the regulation of the environment and natural resources.
** Organization involved mainly in the development and use of water resources.
*** Organization involved mainly in the data collection and processing of data/information for water resources management.

There are two existing laws relating to land management in Ghana. These are:

- Land Planning and Soil Conservation (Amendment Act 1975 and Land Planning and Soil Conservation Ordinance, 1953).
- Control of Bushfire Law PNDCL 46.

State agencies that have key responsibilities in land administration in the country are:

- Land Commission established by Act 483 of 1994
- Administrator of School Lands
- Land Valuation Board
- Survey Department
- Land Title Registry
- Town and Country Planning Departments

4.5 Mali

In Mali, the water sector is under the Ministry of Mines, Energy, and Water. Its function is carried out by the National Department of Hydraulics, which was established by the law No. 99-023 of June 11, 1999.

The functions of the department, among other things, include the assessment of potential water resources in the country, supervision of works and appraisal of projects in the water sector, and promotion of sub-regional cooperation in the domain of water resources management.

A number of departments are also involved in the management of water resources. To avoid duplication and harmonize activities, a Committee of Interministerial Coordination of Water Sector and Sanitation was established by decree No. 95-447/PM-RM. The composition of the Committee reflects the ministries involved in water issues:

- The Ministry in Charge of Hydraulics
- The Ministry in Charge of Planning
- The Ministry in Charge of International Cooperation
- The Ministry in Charge of Public Health
- The Ministry in Charge of Agriculture
- The Ministry in Charge of Livestock

- The Ministry in Charge of Environment
- The Ministry in Charge of Territorial Administration
- The Ministry in Charge of Finances
- The Ministry in Charge of Industry
- The Ministry in Charge of Cottage Industry

The Ministry in Charge of the Environment is responsible for all issues affecting the environment. However, the management of the environment is shared among ministerial departments, which include: Rural Development, Health, Hydraulics, Transport, Urban Development, Industries, Education, Public Works, and Territorial Administration.

A number of laws regulate economic and social activity in order to protect the environment. The Preamble to the Malian Constitution states that the people of Mali must insure the cultural inheritance and environmental protection. Some of the laws and regulations governing the water sector in Mali include the (i) The Water Code, (ii) National Policy on Water, (iii) The Code on Decentralised Territorial Communities, and (iv) National Strategy on Development of Potable Water Supply and Sanitation. Other laws governing the environmental sector include Law No. 91-047/an-rm and the Law No. 89-6/an-rm. Other laws govern land ownership and the management of forest resources.

4.6 Togo

In Togo, a number of institutions are involved in the management of water and soils. The various ministries and departments involved are presented in Table 4.6-1.

Table 4.6-1. Ministries, Departments, and Institutions Responsible for the Management of Water and Soils in Togo

Ministry	Department/Institution	Responsibility
Ministry of Equipment, Mines, and Hydraulic Resources	General Department of Hydraulics	Implementation of programmes, formulation of laws and regulations with respect to water resources and sanitation
Ministry of Public Health	Division of Public Health and Sanitary Engineering	Public hygiene and sanitation
Ministry of Public Health	National Institute of Hygiene	Analysis of water
Ministry of Agriculture, Animal Husbandry, and Fishing	Department of Managing Rural Equipment	Management of surface water, Agro land laws
Ministry of Environment and Forest Resources	Department of General Ecology and Rehabilitation of the Environment	Control of withdrawal of water from water courses, aquifers, lagoons, and the sea for industrial and agricultural purposes

Ministry	Department/Institution	Responsibility
Ministry of Agriculture, Animal Husbandry, and Fishing	Togolese Institute of Agricultural Research (ITRA)	Conservation, studies, and mapping out of soil types
Ministry of Planning and Management of Territories, Habitat, and Urban Development	Department of Urban Development and Habitat	Control of the management of urban lands
Ministry of National Education, University of Lome		
Ministry of Cooperation and Foreign Affairs		

The legal framework governing the management of land and water resources is the Code for the Environment, the decree of 5 February 1933, and Code for Water, which is to be finalized under the management of water resources, and the Mining Code.

4.7 Overview of national institutional and legal framework for integrated management

In the riparian countries, many institutions are charged with the responsibilities of managing water and soil resources. This results in the overlapping of responsibilities and difficulties in coordination. Coordination of activities among the institutions was found to be generally weak, and in some cases is only on an *ad hoc* basis for crisis situations. In order for the management of water and soil resources to be effective, it should be integrated at the local and national level, with emphasis on intersectoral coordination.

The effectiveness of the laws governing resources poses another problem as the laws and regulations established for the management of water and soil resources appear to be weak and ineffective. In some instances, the laws are adequate but they are not adhered to or enforced either due to lack of institutional capacity or political commitment. The knowledge base of the state of natural resources, rate of depletion, and consequent future impact is poor, and probably contributes to the weak political commitment on the parts of governments and general apathy on the part of the populace.

4.7.1 Regional Coordination

Several initiatives have been undertaken at the regional level to manage water resources. One such process initiated by the Government of Burkina Faso, with the support of DANIDA (Danish International Development Agency), brought together official delegations from 16 West African countries to form the West African Regional Action Plan for Integrated Water Resources Management (WARAP – IWRM). Begun in 1997, this regional cooperation arrangement within the Economic Community of West Africa States (ECOWAS) has proposed the establishment of a regional structure for coordination and monitoring of the West African Regional Initiatives for Integrated Water Resources Management. Some of the IWRM country initiatives identified for support include:

- GIRE *(IWRM)* in Burkina Faso
- Water resources management in Benin
- WRIS project for water resources monitoring in Ghana
- Establishing the Water Resources Commission in Ghana
- The sub-regional action plan for combating desertification adopted in 1999 by the environment ministers

Another regional cooperation effort for integrated management of water resources is being developed by the Global Water Partnership and its technical group, the West African Technical Advisory Committee (GWP/WATAC). Their aim is to prepare regional Programmes of Action to implement the West African Water Vision for the twenty-first century.

A sub-regional initiative, Comité Permanent Inter Etats de Lutte Contre la Sécheresse (CILSS), limited to the Sahel region, considers how to fight drought and desertification with the view to promoting food self-sufficiency in the region.

Green Cross International, with its sub-regional head in Burkina Faso, is also undertaking a basin-wide initiative with the objective to develop basin principles, agreements, and management policies in order to promote peace.

Other initiatives in the region include:

- GLOWA Volta Project on Integrated Assessment of Feedback Mechanism Between Climate Land Use, and Hydrology
- World Bank
- Agence Francaise de Développement
- West and Central Africa Action Plan for Abidjan Convention (WACAF)
- Land-Ocean Interactions in the Coastal Zones (LOICZ Afribasins project)
- Center for Africa Wetlands (CAW)

Two other regional initiatives have direct bearing on the Volta River Basin environment. The New Partnership for Africa's Development (NEPAD) is a comprehensive integrated framework for the socio-economic development of Africa, and contains a strong environmental component. Additionally, two basin countries (Côte d'Ivoire and Ghana) participate in the African Process. Implemented through a GEF Medium Sized Project by UNEP, the African Process has developed a series of concrete projects that effectively address problems identified as having adverse impacts on the sustainable development of the marine and coastal environment in sub-Saharan Africa. This TDA and the ensuing Strategic Action Programme draw upon the interventions developed under these two programs.

Bilateral cooperation also exists among the riparian countries for mitigating some environmental issues and problems. Such cooperation efforts include the Burkina Faso – Ghana Joint Committee for managing the water resources of the Volta Basin; Burkina Faso – Côte d'Ivoire Committee for the development of programmes for integrated management of water and cooperation in matters of the environment and forest, etc. Table 4.7-1 provides details of some of the existing bilateral cooperation efforts.

Table 4.7-1. Bilateral Cooperation Among Riparian Countries

Countries	Areas of Cooperation
Burkina Faso - Côte d'Ivoire	• Demarcation of borders • Cooperation in matters of the environment and forest • Harmonization of geological cartography of border zones • Development of programmes of integrated management of water resources • Transhumance and sanitation issues
Burkina Faso - Ghana	• Finalization of border demarcation • Fight against epidemics • Pipeline project • Creation of joint commission on the management of water in the Volta Basin • The dam project of Noumbiel
Burkina Faso - Benin	• Rehabilitation of transnational highways • Transhumance and sanitary issues • Poaching
Burkina Faso - Togo	• Transhumance and sanitary issues • Demarcation of tripartite boundary • Exchange of experience in matters of soil and water
Burkina Faso - Mali	• Fight against bushfires • Protection of elephants of Gourma and the management of their movement • Fight against desertification • Roads

Regional institutions, such as the Economic Community of West African States (ECOWAS) and the Economic and Monetary Union of West Africa (UEMOA), all have within their purview the promotion of the integrated management of the natural resources of the region for social and economic development. At the moment, though, a coordinated framework for holistic management of the natural resources (water and land resources) and the ecosystem of the Volta Basin for sustainable development does not exist.

4.7.2 International Cooperation

The riparian countries are also party to a number of international agreements that are relevant to the protection of the environment in the Volta River Basin. All six of the Volta countries are parties to the conventions listed in the table on the next page (Table 4.7-2).

Additionally, Côte d'Ivoire, Ghana and Togo are parties to Tropical Timber Agreement 83 and Tropical Timber Agreement 94. Benin, Mali, and Togo are parties to the Convention on Conservation of Migratory Species. Finally, all of the riparian countries except Togo and Ghana are parties to the Basel Convention on Hazardous Waste.

None of the countries, however, is party to the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention).

Table 4.7-2. Dates of Ratification of Major International Environmental Conventions

CBD	Biological Diversity	Ramsar	Climate Change	Montreal Protocol	CITES	World Heritage	Desertification
Benin	30/06/94	24/05/00**	30/06/94	01/07/93*	28/02/84*	14/06/82	29/08/96
Burkina Faso	02/09/93	27/10/90**	02/09/93	20/07/89	13/10/89*	02/04/87	26/01/96
Côte d'Ivoire	29/11/94	27/06/96**	29/11/94	05/04/93*	21/11/94*	09/01/81	04/03/97
Ghana	29/08/94	22/06/88**	06/09/95	24/07/89	14/11/75	04/07/75	27/12/96
Mali	29/03/95	25/09/87**	28/12/94	28/10/94*	18/07/94*	05/04/77***	31/10/95
Togo	04/10/94*	04/11/95**	08/03/95	25/02/91	23/10/78	15/04/98***	04/10/95***

* accession
** entry into force
*** acceptance

5.0 Major Perceived Problems and Issues

The identification of the major perceived[1] problems and issues (MPPI) is a first step in the TDA process and it constitutes the justification for the subsequent in-depth analyses. The significance of the perceived issues and problems should be substantiated on scientific, environmental, economic, social, and cultural grounds. The MPPIs should represent the perceptions of the scientific and expert community on the priority environmental issues of the region. The experts may come from the scientific community, the NGO community, government, and other stakeholder groups.

This section of the TDA analyzes the MPPIs to identify the technical basis supporting or refuting each MPPI as a priority issue in the Volta River Basin. The intent is to provide a technical rationale for prioritizing the MPPIs, to help guide the direction of future interventions to improve the Volta River Basin environment. It will be of no use to identify major intervention efforts for an MPPI if the technical basis supporting its priority is missing. In such a case, either the MPPI can be dismissed as a non-priority issue, or just as importantly, gaps in knowledge can be identified, and filling the gaps can become the next step towards addressing that particular MPPI.

This section, therefore, relies on the literature generated in the national reports, to determine the technical basis for each MPPI. The major sources of information are listed within each individual section as well as in the References accompanying this TDA. Given the limited size of this TDA, not all information available in the region can be included in this section.

The following list of major perceived problems and issues was finalized at the second regional meeting of the national coordinators. The National Coordinators prioritized the MPPIs as is indicated in the following table. A summary analysis of each MPPI follows.

Table 5.0-1. Analysis of Prioritized Land and Water Issues

Problem/Issue	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Togo	Basin Average	Rank
Land Degradation	8.5	7.5	8.5	8	10	9	8.6	1
Flooding	5.5	6	4.5	5	10	7	6.3	6
Water Scarcity	8.5	9.5	8	7	9	9	8.5	2
Growth of Aquatic Weeds	5.5	6	5	7	7	7	6.3	7
Loss of Biodiversity	7.5	7.5	8	7	9	8	7.8	4
Water Quality Degradation	6	8	7.5	6	9	8	7.4	5
Water-Borne Diseases	8	8.5	8	7	9	8	8.1	3
Coastal Erosion	6	-	-	5	-	6	5.7	8

[1] "Perceived" is used to include issues which may not have been identified or proved to be major problems as yet due to data gaps or lack of analysis or which are expected to lead to major problems in the future under prevailing conditions.

The regional prioritization indicates that land degradation, water shortage, water borne diseases and loss of biodiversity are of great concern to the riparian countries. Water quality degradation, waterweed infestation, flooding and coastal erosion are also of concern, but to a lesser degree.

Additionally, two emerging problems and issues were identified: urbanization and an increase in industrial and mining activities.

Below, each of these problems and issues is addressed from a status perspective. This is followed by a causal chain analysis that determines the primary, secondary and root causes for the problems/issues. This TDA attempts to clarify the linkages between root causes and perceived problems, to encourage interventions at this more sustainable level. Fortunately, root causes are common to a number of different perceived problems and issues, so addressing a few key root causes may have positive effects on several problems and issues (Table 5.0-2).

Table 5.0-2. Root Causes and Major Perceived Problems and Issues

Root Causes	Perceived Problems							
	MPPI 1	MPPI 2	MPPI 3	MPPI 4	MPPI 5	MPPI 6	MPPI 7	MPPI 8
	Land Degradation	Water Scarcity	Loss of Biodiversity	Flooding	Water-Borne Diseases	Growth of Aquatic Weeds	Coastal Erosion	Water Quality Degradation
Insufficient scientific capacity	√		√	√	√		√	
Low government priority on environment	√	√	√	√	√		√	
Abuse of power	√	√	√	√	√		√	√
Poverty	√	√	√	√	√	√	√	√
Insufficient knowledge / understanding	√	√		√	√	√		√
Population pressure	√			√				√
Inadequate legal / regulatory basis	√	√	√	√	√	√		√
Inadequate technical infrastructure	√		√	√	√	√		
Insufficient demonstration projects	√	√		√	√		√	√
Inadequate intersectoral coordination	√	√			√			√
Insufficient economic incentives	√	√	√	√	√	√		√
Inadequate political will	√		√	√	√	√	√	√
Inadequate water basin management	√							
Insufficient regional agreements		√		√		√		√
Drought		√						
Inadequate human capacity			√					
Inadequate institutions	√	√	√	√		√		√
Inadequate technology		√	√		√			
Insufficient government power	√	√	√	√	√	√		√
Inadequate training					√			√

5.1 Land Degradation

a. Status of the problem/issue

The problem of land degradation in the basin encompasses soil degradation, intense erosion and desertification. As discussed in Section 3 above, the basin's population is heavily dependent upon the land resources of the region for subsistence agriculture and livestock breeding. The increasing demographic pressures have resulted in the overuse and misuse of land resources. Soil degradation, erosion, and desertification processes manifest themselves in low agricultural productivity, destruction of the soil's natural productive capacity, compacting of the soil, degradation of water quality, and loss or reduction in vegetation cover. The increased mobility of sediments also affects reservoir capacities and their useful lives.

Farming and animal husbandry are significant contributors to land degradation in the basin. Agricultural practices in the basin have in the past included crop rotation and leaving fields fallow for a period of time. With rising population, however, the fallow periods have been reduced and crop rotation declined, leading to the loss of soil fertility and less food production per unit area of cultivated land. Increasing livestock production has resulted in the loosening of soils and the degradation of vegetation, both of which exacerbate erosion.

Increased exploitation of forested areas is also a significant contributor to soil degradation and erosion. Forested areas are cut to provide additional lands for agriculture and animal husbandry, and to provide fuel. Additionally, timber resources are over-exploited in many parts of the basin. This is done to meet rising demands for foreign exchange, as well as to meet increasing domestic needs. Unfortunately, the timber exploited is not processed for higher value and thus more volume of timber is required to be exported for adequate foreign exchange receipts for the countries' socio-economic development. In the long-term, these practices are not sustainable and have detrimental effects on both land and water resources in the region.

See Figure 5.1-1 in Appendix D for a map of areas experiencing bushfires, and Figure 5.1-2 in Appendix D for a map of areas experiencing land degradation in the basin.

b. Transboundary elements

The problem of land degradation in the region has both transboundary causes and effects.

Transhumance, defined as the movement of cattle, sheep, and people across national boundaries, is common within the basin. This phenomenon is usually accompanied by reckless destruction of vegetation, watering sources, etc. The situation also creates social tension and disruption of socio-economic activities, sometimes proving fatal.

Bushfires have no respect for national boundaries and can move from one country to another country in the basin. This phenomenon of bushfire across frontiers does happen in the basin and constitutes a transboundary cause. While controlled bushfires are used to enhance the fertility of agricultural lands, many of the bushfires intentionally or unintentionally occurring in the region can quickly get out of control and burn large areas.

Deforestation occurs across frontiers, particularly where transhumance is a major problem as in the basin. The animals being moved are fed on leaves of trees illegally cut down by the herdsmen. Additionally, the pounding of the soils by the hooves of the animals renders the soil loose for erosion. Deforestation also occurs across borders when there are inadequate laws in neighboring countries. For example, people from Burkina Faso travel to Mali because the laws are less strict there.

Population pressures in countries with a weak economic base, as in the basin, induce unsustainable use of forest and land resources. The easy movement of people across national boundaries in the sub-region under the ECOWAS protocol makes population pressure a transboundary cause of the above-mentioned environmental problems in the basin.

The transboundary nature of the effects of soil degradation and erosion arise mainly in the sediment transport and degradation of water quality. Due to erosion occurring upstream, sediments are filling river channels and reservoirs, and decreasing water quality. Additionally, the transhumance of livestock occurs when new pastures must be found due to land degradation.

c. Environmental impacts

Major environmental impacts of land degradation include:

- High concentration of suspended solids
- Siltation of waterways and reservoirs
- Increased stormwater run-off
- Reduced water infiltration into soil and aquifers
- Degradation of water quality from increased use and run-off of fertilizers
- Loss of habitats and biodiversity
- Desertification
- Reduction of soil productivity, reduced animal and crop production

d. Socio-economic impacts

Soil degradation, intense erosion and desertification have significant socio-economic impacts in the basin. Some of these include:

- Reduction in water for irrigation and human needs
- Reduction in productivity of agricultural lands
- Reduction in productivity of pasture lands
- Decreased availability of agricultural and pasture lands
- Decreased forestry resources
- Loss of medicinal plants
- Increased competition over land resources
- Migration of populations to find fertile lands
- Decreased food security and ensuing effects on human health
- Reduction in hydroelectric power capabilities
- Increased poverty and disease

Socio-economic impacts related to land degradation are extensive, but difficult to assess. Land degradation, however, has serious consequences on the ability to produce food in the region, which in turn has serious consequences on human health and security.

e. Causal chain analysis

See Appendix B.

Major root causes include:

- Insufficient scientific capacity
- Low government priority on environment
- Abuse of power
- Poverty
- Insufficient knowledge/understanding
- Inadequate institutions
- Population pressure
- Inadequate legal/regulatory basis
- Inadequate technical infrastructure
- Insufficient demonstration projects
- Inadequate intersectoral coordination
- Insufficient economic incentives
- Inadequate political will
- Inadequate water basin management
- Insufficient government power

f. Sectors and stakeholders

Some of the stakeholders in the region include:

- Subsistence farmers in the basin
- Population dependent on forestry resources
- Basin population engaged in animal husbandry
- Hydroelectric power authorities and users
- Agencies and institutions responsible for environmental protection
- Companies and basin population engaged in mining activities

g. Supporting Data

Benin

Only a small amount of land is suitable for agriculture, livestock, and for dwellings in the Volta Basin of Benin. As a result, competition exists over these finite resources and the region is experiencing significant demographic pressure. This land pressure is also hindering economic development in the region.

The majority of land in the basin is owned and is passed down through families, rather than sold to outsiders. Additionally, communes remain under the control of managers who determine how lands are divided. Thus, the land tenure system remains somewhat traditional as local leaders have significant control.

Land resources in the basin are seriously threatened by anthropogenic activities, and this in turn threatens waterways. The overexploitation of the vegetation occurs as a result of overgrazing of livestock caused by the increasing density of the zone's population. The abusive use of artificial fertilizers and pesticides, the reduction of the duration of fallow periods, and other poor agricultural practices scour the land and deplete the soil's minerals. Bushfires accompanied by hard rains and strong winds further accentuate erosion and add to the sedimentation of waterways. Further, the destruction of forests and the deforestation of riverbanks exacerbate the degradation of the land and threaten the Oti River.

Table 5.1-1. Characteristics of the Zones

Agro Zones	Ecological Practices of Agricultural Systems	Problems	Causes
• West Atacora • Cotton • Oti National Park	• Burning of biomass • Farming of hollows • No use of mineral manure • Food crops: sorghum and millet, niébé, groundnut, fonio, voandzou, yam, maize, and rice • Breeding: system of breeding based on transhumance and changing pastures	• Degradation of the soils and vegetation cover • Food security • No market for groundnut and rice • Conflicts between livestock breeders and farmers	• Farming practices • Demographic pressure • Ferruginous soils with inadequate water and poor fertility except in the hollows • Lack of water sources and pasture

Burkina Faso

Land in Burkina Faso is threatened by agricultural practices, deforestation, and, in some areas, by mining activities.

In the Mouhoun Basin, land tenure is based on social stratification. It is also based on the right of collective appropriation distributed between the founders of a village and the right of temporary or permanent use of the land allotted to an individual. Individual appropriation does not exist, however, and land rights can only remain within the social group.

In the Nakanbé Basin, land tenure is related to the existing structure. The area is occupied primarily by animal herders who require a large amount of land for pasture, but the land is not used intensively. The land is collectively owned by the group, and they do not have the right to refuse an outsider use of the land if they have valid reason.

Forested areas in Burkina Faso are shrinking significantly as population pressure in the region increases. In the National Action Plan for the Fight Against Desertification (1999), it is noted that forested areas decreased by 1.26 million hectares between 1980 and 1992.

In short, the occupied surfaces in the basin are:

- agriculture: 3,000,000 hectares
- water reserves: 83,000 hectares
- human habitats: (not estimated)
- roads: 34,000 hectares
- classified forests: 788,500 hectares
- For a total of: 3,905,500 hectares.

This surface represents 22.5% of the total surface of the basin.

Côte d'Ivoire

The rural areas in the basin tend to follow the traditional system of tend tenure. At the village level, each "great family" has a field on which the members cultivate. The appropriation of the ground is thus collective, but its exploitation is individual.

Today, land and water resources are subjected to the modern system of land tenure defined by the laws of the Rural Land Code and Water Code promulgated in December 1998. These laws aim to protect the resources from overexploitation.

As in the rest of the basin, agriculture is the dominant economic activity and a significant contributor to land degradation in the Volta Basin of Côte d'Ivoire. Cotton is a main crop in the area, as well as anacarde, corn, sorghum, rice, and groundnuts.

The area is also used as pastureland to a significant extent. Herders come from Mali and Burkina Faso to use lands in Côte d'Ivoire.

Bushfires are used extensively in the region in hunting, managing pastures, preparing agricultural lands, and for other purposes. Uncontrolled bushfires contribute to land degradation.

The lands in the basin are occupied approximately in the following manner:

3% Infrastructure, urban areas, water, and rocky zones
12% State-owned land: national parks and reserves
75% Rural areas (50% savannah and forest, 25% cultivated)

Ghana

Land ownership within the basin is basically traditional except for areas demarcated for control by the government agencies, such as the Volta River Authority, as well as forest reserves, wildlife, and national parks. The details of traditional ownership vary from place to place. As the system vests all resources under the control of the traditional authorities. Families and individuals have both access and control of resources through birth into a particular community

or after payment of certain amounts either in kind or cash (Nyankpala Agricultural Research Station (NAES), 1989) In the northern sector of the Volta Basin, usufruct rights to land might not necessarily include rights to economic trees like the dawadawa and shea trees (NAES, 1989). While individuals and families might own lands along riverbanks, the rivers always remain communal or public property and are used as such.

Agriculture is the dominant economic activity within the Volta River Basin. As in other areas of the basin, soil is being rapidly degraded as a result of shortened fallow periods. This is especially pronounced in the northern parts of the basin

Environmental problems arising from livestock production are becoming sources of great concern. The maintenance of large herds of livestock has tended to exceed the carrying capacity of the ecosystem, particularly in the northern part of the basin where mean annual rainfall is about 1000-1200 mm. During the dry season of November to April, large herds of cattle cross from the neighboring countries to graze on the limited fodder available. This severely exposes the soil to erosion, and watersheds to rapid evaporation. The prolonged exposure of the soil renders it susceptible to erosion and reduces its regenerative capacity. In the northern parts of the basin, large tracts of arable land have become infertile and crop yields have declined tremendously.

Table 5.1-2. Erosion Hazards of the Volta Basin in Ghana

Volta Basin System	Erosion Hazard
Black Volta	• Northern Section: slight to moderate sheet erosion. • South-western Section: A combination of moderate to severe sheet and gully erosion but more of the latter with areas of very severe sheet and gully erosion. • SE Section: A combination of moderate to severe sheet and gully erosion but more of the latter.
White Volta	• Same as in the Black Volta Basin
Daka	• Combination of sheet and gully erosion but more of the former.
Oti	• Combination of moderate to severe sheet and gully erosion but more of the latter, especially within the central and southern sections
Lower Volta	• NS – Combination of moderate to severe sheet and gully erosion, especially the southern parts. The extreme northern part is however subject to slight sheet erosion. • CS – Moderate to severe sheet and gully erosion but more of the latter. • SS – Slight to moderate sheet erosion within the savannah areas and severe to very severe gully erosion within the forest and highland areas. • ES – Severe to very severe sheet and gully erosion but more of the latter.

As increasing populations look for additional lands to farm, deforestation often occurs. Although figures are not known for the Volta basin, nationally deforestation occurs at a rate of

2.5-5% annually in areas that are not forest reserves. Within forest reserves, deforestation occurs annually at a rate of 1.3%.

Bush burning, used to clear land for agricultural purposes, hunting, creating fire belts at the onset of the dry season, and inducing rapid re-growth of rangeland during the dry season, often results in enormous damage to vegetation, wildlife, and properties because they typically are not controlled. The risk of bushfires are highest on the grazing lands in the savannah zones of the basin where as many as 120 to 150 outbreaks can occur within a single year. Along the border areas of the savannah zone, particularly in the Oti, White Volta, and Daka Basins, the problem of bushfires is especially severe, probably as a result of the association with transhumance.

Urbanization in Ghana is another cause of land degradation in several areas within the basin that are becoming population nodes as people migrate from the rural areas to urban centres in search of a better livelihood and to escape tribal conflicts. Settlement growth in areas of the basin considered to be potential biodiversity conservation priority areas, particularly in the White Volta and Lower Volta Basin, is of great concern as important habitat is lost. Although no population statistics are available, however, it is believed that the population in designated protected areas within the basin has not changed significantly over the past decade.

Another problem associated with rapid urbanization is that infrastructure development often lags behind population growth resulting in the development of poor sanitation situations that adversely affect surface water resources. A report by EPA (2001) shows that surface water resources close to urban centres have exceptionally high fecal coliform counts.

Mining is a final cause of land degradation. Several small-scale artisanal groups carry out gold mining in areas underlain by the Birimian formation with little regard for environmental protection. As a result, their operations have led to serious degradation of the land in portions of the Black Volta and White Volta Basin. Limestone mining in the Black Volta basin and in the Lower Volta is also causing damage to land.

White Volta Basin

Predominant land use is extensive land cultivation two-to-six miles from the village on upland areas (NAES, 1993), with widespread grazing of large numbers of cattle and other livestock up to 100 cattle/km^2 (FAO, 1991); and compound cropping (home gardening) around the house (Wills, 1962; Adu, 1967: USAID/ADB, 1979; FAO, 1963; NAES, 1993). Estimates of land use and land cover in 1989 showed that about 50% of the land in the northeast and northern parts of the basin were in the compound and bush fallow cultivation cycle (IFAD, 1990). Farm sizes are usually less than 3 acres. Grazing lands including those obtainable under natural condition are generally poor. Annual bush burning further reduces the quality and quantity of fodder.

Extensive valley bottoms in many parts of the basin, particularly in the guinea savannah areas, have in recent years been cultivated for rice under rain-fed conditions. In the north and northeast, the best agricultural soils are derived from granites, sandstones, and greenstones. These areas remain the most densely populated.

A long period of overcrowding in the upland areas away from the valley bottoms, which had been infested with the *Onchocerciasis simulium* vector, and the intensive cultivation and grazing without proper management practices have led to widespread soil erosion and loss of fertility of the upland soils (Hunter, 1967, Samba, 1994). Outcrops of rocks, iron pan soils, as well as the scarps are usually avoided by farmers and may be uninhabited or only sparsely inhabited. Fuelwood and other wild produce gathering is widespread.

Urban land use is small and most intensive in such centres as Bolgatanga, Bawku, Wa, Navrongo, Tamale, and Tumu. Due to the decentralisation of administration to the district level, urban type land use is becoming important in some of the district capitals, especially those along major trunk roads (Walewale).

Black Volta Basin

The major land use is agriculture with food crop cultivation under extensive bush fallow. The major food crops include yam, cassava, maize, sorghum, millet, groundnuts, and beans. Animal grazing on the free range is a significant activity. Animal numbers are large in the northern and middle parts of the basin in Ghana.

In the northwest of the basin, particularly the Lawra district, lands are highly degraded both in terms of physical status and fertility levels and can hardly support meaningful crop cultivation. Vegetation has also been degraded due to the incidence of annual bushfires. This has led to seasonal human migration and great reduction in the number of livestock.

Lower Volta Basin

Current land use is short bush fallow cultivation along the immediate banks of the river, and less intensive bush fallow cultivation elsewhere. Animal grazing is common while the lakeshores are extensively settled by fishing families. Charcoal burning involving the cutting of wood has become an extensive economic activity in the southern dry forest and transitional environments (e.g., various parts of the Afram sub-basin.)

The Afram plains and other areas in the south have been the focus of increasing settlement and agricultural development since the 1960s, having been generally thinly populated in the past as part of the empty “middle belt” (Dickson and Benneh, 1987). The forest and transitional areas are intensively farmed with cocoa, coffee, plantain, cocoyam, cassava, oil palm, and maize on small bush fallow plots. A large modern commercial farm at Ejura specialises in maize production. Some timber extraction takes place in these areas.

Recent developments, particularly below the Akosombo Dam, include irrigated rice, sugar, and vegetable cultivation in the areas immediately adjoining the Volta River. The construction of the Akosombo Dam has reduced the annual flooding in the Lower Volta lands.

The areas around the coastal lagoons, such as the Songhor, are used for salt mining. Urban land use is limited to a few towns including Kpandu, Kwamekrom, Akuse Sogakpe, and Ada-Foah.

Oti Basin

Current land use and land cover are extensive bush fallow cultivation and grazing with tree savannah regrowth and small patches of reserved forest areas on the hills in the southeast. The main crops that are grown in the basin include yams, guinea corn, maize, rice, millet, and groundnuts.

Fishing is common along the river while grazing, as in other parts of the savannah, is commonly practiced. Settlements within the basin are small.

Daka Basin

The predominant land use is bush fallow cultivation of yams, maize, and guinea corn with free grazing animals. A recent land use problem within the greater part of the Volta basin especially in Black Volta, White Volta, Afram, Dakar, and Oti sub-basins is the activity of alien herdsmen who graze their large herds of cattle indiscriminately, leading to widespread destruction of vegetation and even crop farms. In some cases bushfires are set to hasten to re-growth of fresh vegetation leading to high rates of soil erosion and loss of soil productivity.

Mali

Land in Mali officially belongs to the state. This ownership, however, does not preclude the traditional authority, which manages land ownership according to the following criteria:

- The water and land belong to the head of the land (first occupants and their descendants). This title can be passed down through the family.
- These grounds can then be yielded, lent, pawned or sold to a third party.
- Village leaders play an important role in resolving land disputes.

Approximately 80% of the land in the basin is used for agriculture, livestock, or dwellings. The high population density in the region places enormous pressure on the land. There is competition between the livestock breeders and the farmers for scarce land and water resources. Resulting in part from the increasing population pressure on the land, agricultural practices are not sustainable. Lands are no longer allowed to lie fallow for a sufficient amount of time before they are replanted.

The basin of the Sourou River is considered to be the granary of the country, but poor agricultural practices have steadily degraded the land. The lands are now no longer very fertile and are prone to wind erosion. The degradation of the soil in Mali has resulted in a decline in production from 4 to 20% in the sahel zone and 8 to 20% in the soudan zone.

There is a great deal of competition for resources between those engaged in agriculture and those raising livestock. The droughts in the northern region of Mali have resulted in livestock herders migrating into the Sourou region to find water. This transhumance results in significant destruction of the forests of Samori.

Togo

In Togo, the land resources are governed by a combination of local and tribal leaders and the national government.

Degradation of the land in Togo results from a variety of factors. First, trees are harvested at an unsustainable rate in some areas as the demand for wood has increased. This increases erosion and desertification as the land cover is removed. Second, poor agricultural practices, such as the misuse or overuse of pesticides and fertilizers, have damaged soil resources. Finally, overgrazing of the land further exacerbates the problems of erosion and desertification.

Forest resources in Togo have experienced extensive degradation in recent decades due to population increase, unsustainable cutting of trees for firewood and charcoal, unsustainable cutting of sawlogs, clearing for agricultural use, and bushfires. The forests of the Volta Basin provide more than half of the national production of sawlog, and during the political crisis of the 1990s, much illegal cutting of forests took place. At the national level, it is estimated that forest cover is degraded at the rate of 15,000 ha/year.

While there are significant protected areas in Togo, these have been threatened by encroachment from those populations living around the reserves. In 1992, a national commission was formed to examine the areas facing the greatest threats, which suggested turning towards participatory management of protected areas.

Since 1970 when coffee and cacao trees and cotton production were introduced into the region, vegetation cover in the region has changed. During that period, there was significant immigration into the region as people came to grow these products. Considerable amounts of land were cleared in order to make way for agriculture and livestock production. The agricultural practices, including shortened fallow periods, used in the region often result in land degradation. The following graph shows that the areas under cultivation will continue to increase over the next decade:

Table 5.1-3. Rate of Occupation of Cultivable Land in the Basin in Togo (1,708,800 ha)

Years	Cultivable Area (ha)	Cultivated Area (ha)	Rate in %
1990	1,456,188	264,030	15.45
2000	1,291,759	434,014	25.39
2010	1,087,310	646,784	37.85
2020	782,632	963,862	56.4
2025	578,179	1,176, 637	68.85

Source : Projection à partir des données des Recensements Nationaux de l'Agriculture (1972, 1982, 1996 – DESA)

Livestock are also taking a significant toll on soil productivity in the region. Although there are little data on the specific effects of livestock, it is clear that they are negatively influencing the area.

The areas that have experienced the most severe degradation include the Savannah and Kara region. The areas of Plateau (Danyi), the Central region (Fazao), Kara (Kantè), and Savannah (Dapaong) have experienced strong degradation. The areas of Plateau (Danyi), Power Station, and of Kara experienced average degradation. The zones with weak degradation extend around

the Togo Mountains, in the Plateau area (Danyi and Wawa), in the Savannah area (Mandouri), and Kara (National Park of Kéran).

Table 5.1-4. Evolution of Various Vegetation Formations in Togo (1979-1991)

Vegetation	Area (km²)		Variation in % of the area
	1979	1991	
- Dense forests	2931	1264	- 56 %
- Mountainous forests	863	525	- 39 %
- Dry dense forests	677	315	- 53 %
- Regrown forests	1159	615	- 47 %
- Savannahs with trees	12922	6048	- 53 %
- Shrub savannahs	5138	2720	- 47 %
- Agriculture zones and others	1840	1944	+ 5,6 %

In the area of strongly degraded savannah, the soil erosion was evaluated in 1969 to be between 1,500 and 2,000 tons per km^2 annually. The prefecture of Oti has records from the same time period showing from 600 to 1,500 tons per km^2. These figures can be multiplied by as much as four or six times to account for the current level of degradation (Kpongou, 1994).

The zones with weaker degradation are currently threatened by the phenomenon of savannisation and from impoverishment of the soil due to the disappearance of forests.

h. Data and information gaps

While the causes and effects of land degradation have been described well, supporting data has been provided only sporadically and will need to be augmented in the Final TDA. For many countries, information has not been provided on the areas that are experiencing the most severe degradation, the amount of soil lost to erosion annually, and rates of deforestation and desertification. Nor has a quantification of the loss of productivity of lands been provided for all countries. Additionally, information on demand for land resources in the future has not been given, except in the case of Togo.

5.2 Water Scarcity

a. Status of the problem/issue

As is outlined in the Water Demand Section above, the water resources in the basin do not currently meet the needs of the population. As the basin population may increase by as much as 80% over the next 25 years, water resources are going to become even more scarce. This scarcity is likely to be even further exacerbated by decreased availability of water resources due to climatic and anthropogenic factors.

Changes in the region's climate, largely perceived to result from the emission of greenhouse gases and changes in the hydrological cycle caused by other anthropogenic factors, have and will continue to play a critical role in determining the availability of water resources in the region. Water scarcity arises largely as a result of diminishing precipitation, reduction in river flows, falling water tables, and an increase in the amount of evapotranspiration. Over the past two

decades the basin has seen a reduction in the amount of precipitation and river flows (Gyau-Boakye and Tumbulto, 2000). Lowering of the water tables has also been observed in large parts of the basin. Evidence of a rise in temperatures in the White Volta Basin over a thirty-year period has emerged during a study of climate change impact on water resources (Opoku-Ankomah, 2000).

Human activity in the region also plays a critical role in the availability of water resources. For example, the removal of vegetative cover from land surfaces can reduce infiltration of rainwater to recharge the aquifer system. Thus, stormwater peaks are enhanced while low flows or dry season flows are much reduced. This latter situation can create problems of water scarcity for those who depend on such water resources (i.e., instream flows without adequate storage). Massive deforestation has occurred in the basin and if appropriate measures such as aforestation are not embarked upon, the situation will create drying up of streams and rivers; the use of water resources will therefore not be sustainable.

Reservoirs with large surface areas and shallow depths created for irrigation or hydropower generation have the potential to lose a large amount of water to evaporation. A number of small reservoirs, whose precise number and areas are unknown (more than 400 exist in Burkina Faso alone), have been created in the basin and their losses of water to evaporation cannot be accurately estimated. Continuing construction of these reservoirs into the future without adequate planning and control will lead to the unsustainable use of surface water resources in the basin.

The overuse and misuse of water resources in the region also decreases the availability of water. In the water resources sector, an aspect of over-exploitation in the basin occurs through the excessive pumping of groundwater without due regard to the recharge characteristics of the aquifer system. This situation leads to lack of water during the dry season when water availability is scarce as in the drier parts of the basin in or near the Sahel Zone. Groundwater over-exploitation can lead to saltwater intrusion in the southern parts of the basin near the Gulf of Guinea Coast.

The inefficient use of water resources in the region has exacerbated the problem of scarcity. For example, flooding is the most common irrigation practice in the basin. This approach is very inefficient, however, as it results in water losses through evaporation and deep seepage. More efficient types, such as sprinklers and drip irrigation, may have to be introduced to cut down the water usage.

Water supply systems for domestic and industrial uses have large transmission losses due to leakages, which could be as high as 50%. The expansion of water supply systems for domestic/industrial use does not always match the water demands. The limitation in expansion is due to unavailable financial resources.

While each of the countries forecasts increased demand for water over the next decades, the trends in water use pattern among some of the riparian countries are quite different. For example, there has been a rapid expansion of irrigation in the last 15 years in Burkina Faso of about 934%, while Ghana only experienced an expansion of 95% (Andreini et al., 2002). Ghana,

on the other hand, plans to expand its hydropower generation by constructing the Bui Dam. Thus Burkina Faso, an upstream, agriculturally-oriented country hopes to develop the country's irrigation potential while Ghana, downstream, aims to develop use of hydropower. The trends in water use patterns can potentially generate conflict if the resources are not managed in an integrated fashion.

Please see Figure 5.2-1 in Appendix D for a map of areas showing water shortages in the Volta River Basin.

b. Transboundary elements

Many of the causes and effects of water scarcity are transboundary in nature as water resources are shared among the six countries in the Volta River Basin.

The emission of greenhouse gases in the riparian countries of the basin will be far less than the carbon sinks. Thus the cause of climate change to water scarcity may come completely from outside the basin.

The drying up of streams in the upper sub-catchment of the basin can induce drying up or reduction of flows in the downstream rivers in other countries. Streams upstream can dry up as a result of human induced actions such as deforestation of the headwaters and the forest gallery along the river channels. Thus, altering land surfaces and stream flows in such a way that results in the drying up of streams is a transboundary issue.

Changes of land cover and poor precipitation reduce recharge of aquifer systems. In the basin, some of the scarce aquifers are shared among the riparian countries and human activities in the recharge zone can be a transboundary problem. Also, over-exploitation of groundwater resources through poor water resources development and planning can also create transboundary causes to water scarcity.

Impoundments and reservoirs lose water through evaporation; the larger the surface area of the reservoir, the greater the evaporation. Reservoir systems constructed with large surface areas and shallow depths because of lack of suitable topography can potentially lose large amounts of water and create water deficits downstream.

The effects of water scarcity can also be of a transboundary nature. When there is inadequate water for hydroelectric generation, electricity cannot be exported to those countries in need in the basin, resulting in economic loss. Inadequate water supplies for people and livestock can induce migration across boundaries in search of water resources.

c. Environmental impacts

Major environmental impacts of water scarcity include:

- Loss of biodiversity, including modification or destruction of habitats
- Loss of productivity of soils
- Reduction of fisheries resources
- Reduction in groundwater

d. Socio-economic impacts

The socio-economic impacts of water scarcity are immense. Some of these include:

- Reduction in agricultural production
- Shortage of drinking water
- Increased cost of alternative water supplies
- Decline in drinking water quality
- Effects on human health
- Decrease in forestry resources
- Decrease in animal husbandry
- Reduction in hydroelectric generation
- Increased costs of electricity
- Migration/transhumance
- Increased poverty and disease

The effects and symptoms of this water scarcity are the drying up of rivers that had hitherto been perennial during the dry seasons, women and children walking long distances to fetch water, and people using polluted sources. Other major effects on some of the economies could be reduction in hydropower generation with resultant power curtailment for industrial activities.

e. Causal chain analysis

See Appendix B.

Major root causes include:

- Inadequate technology
- Drought
- Low government priority on environment
- Abuse of power
- Poverty
- Insufficient demonstration projects
- Inadequate legal/regulatory basis
- Insufficient economic incentives
- Inadequate intersectoral coordination
- Insufficient regional agreements
- Insufficient knowledge/understanding
- Inadequate institutions
- Insufficient government power

f. Sectors and stakeholders

Some stakeholders include:

- Population of the basin dependent on water resources for drinking water, agriculture, and animal husbandry
- Population of the basin dependent on forestry resources
- Hydroelectric energy authorities and users
- Government institutions and authorities responsible for water management

g. Supporting data

Benin

The average annual rainfall in the Oti River Basin in Benin is approximately 1100 mm. In normal years, flows are around 58.6 m^3/s, which is equivalent to an annual flow volume of approximately 1.85 x $10^9 m^3$.

Estimation of groundwater resources in the Oti Basin is difficult since these resources are almost inseparable from the groundwater resources of the Niger basin in Benin. The two basins together have a potential recharge of about 2.5 x $10^9 m^3$ per year.

Burkina Faso

The Volta Basin in Burkina Faso is comprised of two main sub-basins: Mouhoun (Black Volta) and Nakanbé (White Volta). Mean annual rainfall in the sub-basins varies from approximately 900 mm to less than 600 mm. Over the past forty years, the precipitation patterns have been of increased dryness, especially between 1970 and 1980. While rainfall increased between 1985 and 1995, the last decades are still marked by the following trends: decrease in river flow, decreased availability of groundwater, the drying up of source waters, and degradation of vegetation cover.

The surface water resources of the basin are made up of stream flows and water in reservoirs. Table 5.2-1 illustrates the distribution of the available surface water resources.

Table 5.2-1. Potential Surface Water Resources of the Volta Basin in Burkina Faso

Sub-basin	Annual Flow Volume (x $10^9 m^3$)	Volume in Reservoirs (x $10^9 m^3$)	Potential in the Basin (x $10^9 m^3$)
Mouhoun (Black Volta	2.64	0.29	2.75
Nakambé (White Volta)	2.44	2.20	3.32
Total	5.08	2.49	6.07

Source: Etat des lieux des resources en eau et de leur cadre de gestion

The estimation of groundwater resources is not very accurate due to the unavailability of data. The total adopted value for the entire basin in Burkina Faso is approximately 20.8 x $10^9 m^3$.

The document on Strategies with Regard to Water evaluated the theoretical availability of the renewable resources to be 1,750 m^3/yr/person for the entire country, with the threshold of shortage usually fixed at 1,000 m^3/yr/person.

In the Volta Basin, according to new estimates, however, there will be available only 3.25 billion m^3 in a typical year and 1.54 billion m^3 in a dry year for a population of 8 million persons, which gives 406 m^3/yr/person and 193 m^3/yr/person, respectively. This volume is indicative of severe water shortages.

Côte d'Ivoire

The lack of hydrometeorological, hydrogeologic, hydroclimatic, water quality, and sediment transport data for the Black Volta Basin makes it difficult to accurately evaluate the surface and subsoil waters in the area.

Surface water resources

Average annual rainfall over the basin is approximately 1000 mm. The surface water resources derived from the Black Volta are about 0.788 x $10^9 m^3$/yr.

There are 43 dams established in the basin, with a storage capacity of 3 million m^3.

Groundwater resources

From drilling undertaken in the basin, the following estimates have been given for the availability of groundwater resources:

- The chances of success for achieving a flow of 0.7m^3/h is between 65 and 80% for a depth for a depth of 65 to 45 meters.
- The potential flow lies between 2 and 5 m^3/h for the withdrawal zone of 21 meters.
- The index of contribution: annual average effective rain is 150 to 325 mm/yr (Peff), providing the local reserve between 150 and 225 million m^3/km^2.

With regard to the replenishment of the underground layer, the results of the study made by F. Lelong in 1966 show replenishment expressed as a percentage for:

- Annual rainfall of 1,200 mm: 24% of this replenishes the groundwater layer.
- Annual rainfall of 1,000 mm: 17% of this replenishes the groundwater layer.

In short, the water resources are estimated to be:

- Annual average rainfall: 1000 mm; or 12,500,000,000 m^3
- Annual historical river discharge: 63 mm; or 787,500,000 m^3
- Recharge of the groundwater: 170 mm; or 2,125,000,000 m^3
- Total available: 2,912,500,000 m^3

This is far short of projected increased demand over the next several decades, indicating that there will be an increased scarcity of water.

Ghana

All the tributaries of the Volta River enter Ghana and converge in the Lower Volta Basin. Rainfall in the basin varies from approximately 1000 mm to 1600 mm.

The surface water resources received annually from outside and within the country are shown in Table 5.2-2.

Table 5.2-2. Water Resources of the Volta River in Ghana

	River	Mean Flows (m^3/s)	Mean Annual Flow (x $10^9 m^3$)
Water resources that originate from outside the country	White Volta	110.7	3.49
	Black Volta	103.75	3.27
	Oti	276.4	8.72
	SUB-TOTAL	490.85	15.49
Water resources from within the country	White Volta	192.57	6.08
	Black Volta	139.55	4.40
	Oti	89.1	2.81
	Lower Volta	289	9.12
	SUB-TOTAL	710.22	22.41
	TOTAL FLOW	1,201.07	37.90

Source: (Opoku-Ankomah, 1998)

The flows into the Lower Volta were based on specific yield of the catchment and may not be very accurate. Approximately 54% of the flows of the transboundary tributary originate from outside the country. An earlier estimation by Nathan Consortium (1970) puts this figure around 70%. This may be explained by the reduction of rainfall magnitudes in the Sahel in the high latitudes of West Africa since the 1970s (Nicholson, 1983). Further, in the case of the Oti River, approximately 76% of the water resources originate from outside the country. The total mean annual flow of the entire river system is estimated to be 37.9 billion m^3.

The groundwater resources, as in the rest of the basin, are controlled by secondary porosities. Aquifers are semi-confined or confined. Yields from boreholes in the country are from about 0.1 m^3/h to 36 m^3/h.

The minimum recharge for the sub-basins within the Volta Basin and replenishable groundwater capacities are presented in Table 5.2-3.

Table 5.2-3. Minimum Recharge and Replenishable Groundwater Capacities

Sub-Basin	Minimum Recharge (mm)	Replenishable Groundwater Capacities (x $10^9 m^3$)
White Volta	151	6.6
Black Volta	205	3.4
Oti	175	3.7
Lower Volta	205	8.2

Interpretation of the information given in the foregoing discussion as to water resources availability should be handled with care as the figures given are annual figures and do not reveal

the seasonal deficits in water resources in the basin. Most riparian countries have deficits of run-off during the greater part of the year. Inter-annual variations of rainfall and run-off are characterized by severe droughts and water shortages.

Mali

Very little data are available on water resources in Mali. Water has been in such short supply in the region that the first priority has been to provide water to the inhabitants, while research was overlooked.

The Sourou River is the main source of surface water in the region. Annual rainfall is approximately 400 mm and surface flows are only ephemeral as streams dry up after 3 to 5 months of the rainfall season. Discharge measurements are limited and available data could not allow for quantitative assessment of surface water resources. However, about 52% of the villages in the region depend on surface water (i.e., streams, lakes, ponds, etc.) for short periods.

The level of water of the Sourou River in Mali increased significantly after a dam was constructed in Burkina Faso in 1989. The valley of Sourou now forms the northern end of the reservoir created by the dam.

The only other sources of surface water are small temporary ponds that appear in Seno during the winter. There are 12 ponds in the southern zone (Dioura) and 9 others in the District of Bankass. They dry up, however, after 3 to 5 months.

The chemical and bacteriological quality of the surface water is generally bad, in large part due to fecal contamination. The polluted water is a source of water-borne diseases.

While those living near surface water resources must depend on groundwater during the dry season, a significant amount of the population must depend on groundwater year-round as they live far from the Sourou River. The depth of the groundwater is estimated to be between 35 and 85m in Seno and 35 and 65m in Samori (PIRT, 1983). Thus, building a reliable well is difficult and expensive.

The number of wells in the region are:

Bankass
343 traditional wells
30 improved wells
46 truck farming traditional wells

Koro
633 traditional wells
68 improved wells
154 truck farming traditional wells.

Nitrates are frequently found in subsoil waters, but at levels below WHO standards for water consumption. Iron has been found at levels above WHO standards. In general, water quality is neutral to basic.

Togo

Togo's water shortage is projected to be exacerbated by the effects of climate change. It is estimated that by 2025, average monthly temperatures will rise from South to North 0.48 to 0.58%, which is 0.8 to 1° C over 1995 levels. Precipitation is expected to decrease 0.1 to 0.3%.

The northern section of the basin receives between 1000 and 1200 mm of rainfall annually, while the southwest region receives from 1000 to 1500 mm per year.

Surface water resources estimated for the basin are about 4.71 x $10^9 m^3$ per year. Most streams dry up during the dry seasons due to high evapo-transpiration. In the northern part of the basin, the Oti, enlarged by its tributaries, and Mô exceed 100 m^3/s in the Savannah region and 100 to 300 m^3/s in the area of Kara. The extreme variability of the flows between the wet and dry seasons makes depending on the surface water for irrigation difficult. In the southwestern section of the basin, the Menou, Wawa, and Danyi have much smaller flows of between 1 and 6 m^3/s, but these are perennial flows as the climate is wetter.

The groundwater resources are estimated to be 4.38 x $10^9 m^3$ per year. Groundwater, as in the rest of the basin, is found in discontinuous aquifers.

h. Data and information gaps

Although there are a number of international projects to evaluate the region's water resources underway, such as the DHI Water and Environment projects, the information on this topic provided by some countries was insufficient. While information on projected demand for water is quite extensive, data on currently available surface and groundwater resources are not as comprehensive. In particular, the Final TDA will need to include additional data on groundwater resources and more extensive data on which areas are experiencing shortages.

5.3 Loss of Biodiversity

a. Status of the problem/issue

The Volta River Basin has a globally significant biodiversity and diverse habitats that are threatened by anthropogenic sources. Perhaps the greatest threat comes from the clearing of land for farming and animal husbandry, as well as from forestry practices. Some farmers use bushfires for land preparation, re-growth of vegetation for cattle grazing, and for hunting purposes, etc., at the expense of the environment. This practice enhances the destruction of habitats, loss of biodiversity, as well as deterioration of biotic resources.

Further, the creation of dams or impoundments can alter hydrological regimes of rivers and streams, and thus alter habitats. Downstream sections of a river below a dam that had been flooded occasionally could completely lose these floodwaters, resulting in the curtailment of growth of organisms associated with these events.

Unsustainable fishing practices in the region result in a reduction in the fisheries. In some areas, destructive fishing gear has been introduced. An interim inventory of biodiversity points to the loss of some fishery species in the basin. This situation is a threat to the food security of the region. Additionally, exotic species have been introduced through fishing practices and as ornamental plants and have caused the destruction of biodiversity.

Excessive hunting and poaching of wildlife in protected areas also occurs and has pushed some species to the brink of extinction. The strengthening of national institutions charged with the responsibility of managing these resources and the enforcement of existing rules and regulations for managing wildlife are required to halt the unsustainable exploitation of these natural resources.

See Figure 5.3-1 in Appendix D for a map of the areas experiencing biodiversity loss in the Volta River Basin.

b. Transboundary elements

The loss of biodiversity and destruction of habitats has transboundary causes and effects. Some of these include:

- Destruction of habitats through bushfires and deforestation occur across borders
- Some forest reserves and protected areas are located at country borders and are vulnerable to poaching and other cross border activities
- Damming of rivers upstream affects the freshwater quality and resources downstream
- Damming of rivers upstream affects the floodplain downstream
- Damming of rivers alters the sediment balance
- Damage to transboundary ecosystems

c. Environmental impacts

Some of the environmental effects of the destruction of habitats and the loss of biodiversity include:

- Loss of natural productivity
- Reduction of fish stocks and other species
- Loss of globally significant biodiversity
- Degradation of forest ecosystems
- Degradation of river ecosystems
- Changes to the hydrological regimes
- Increased delta and coastal erosion

d. Socio-economic impacts

The destruction of habitats by a rapidly expanding basin population leads to a reduction in biotic resources and threatened food security. Some of the socio-economic impacts include:

- Reduction in income from fisheries and hunting
- Changes in employment
- Loss of aesthetic value
- Loss of income from tourism industry
- Loss of cultural heritage

- Loss of use of medicinal plants

e. Causal chain analysis

See Appendix B.

Major root causes include:

- Inadequate national and regional legal/regulatory basis
- Poverty
- Inadequate technical infrastructure
- Inadequate political will
- Inadequate human capacity
- Inadequate institutions
- Inadequate scientific capacity
- Low government priority on environment
- Abuse of power
- Insufficient economic incentives
- Insufficient government power

f. Sectors and stakeholders

Some of the stakeholders associated with the destruction of habitats and loss of biodiversity include:

- Basin population engaged in farming and animal husbandry
- Basin population engaged in fishing
- Institutions responsible for managing protected areas
- Tourism industry
- Hydroelectric power authorities

g. Supporting Data

Benin

Poaching is prevalent in Benin's protected areas. During the dry season, fauna gather in the vicinity of the Oti River. Poachers from Benin, Ghana, and Burkina Faso take advantage of this situation by camping on the banks of the river and then easily preying on the large wild animals.

The poaching in the reserves and parks constitutes the principal problem of the Oti National Park. The park's perimeter is not well controlled in part because the park borders both Burkina Faso and Togo. These zones facilitate the penetration of the park by poachers, resulting in the removal of many species. When park inspections occur, confrontations often take place between poachers and foresters. This results in the loss of human life and the reduction in tourist income.

The fundamental problem now lies in the manner of reconciling the respect of the integrity of the protected areas and the increasing pressure exerted on them. Several aspects must be considered with regard to the impacts on the protected areas. These areas face both internal pressures from the visitors to the parks who do sport hunting and often leave garbage behind, and external pressures from the neighboring populations.

Other threats to habitats and biodiversity in Benin include damage from the practice of bushfires, clearing of the land, and the removal of trees. Additionally, human activities threaten the river ecosystems from the use of artificial fertilizers on farmland that run-off into the waterways.

Burkina Faso

As Table 5.3-1 shows, there are a number of threatened and vulnerable species in Burkina Faso. The results show that the mammal Oryx has disappeared from that country. The ostrich is also near disappearance.

Table 5.3-1. Status of Species in Burkina Faso

Type	Extinct	On the Way to Disappearance	Threatened	Vulnerable	Total
Mammal	• Oryx		• Panther • Cheetah • Elephant	• Damalisque • Gazelle rufifron • Gazelle dorcas • Lycaon	10
Birds		• Ostrich	• Calao d'abyssini	• Grue couronnée	3
Reptiles			• Crocodile • Python		2
Fish				• Protoptère (anguille)	1
Woody Plants		• Celtis integrifolia Adenium obesum	• Acacia senegal • Dalbergia melanoxylon • Pterocarpus lucens • Vitex doniana • Ximenia americana	• Adansonia digitata • Bombax costatum • Ceiba pentandra • Anogeissus leiocarpus • Khaya senegalensis • Prosopis africana • Parkia biglobosa • Butyrospermum • Paradoxum	15

Source: National Monograph on biological diversity

Threats to biodiversity can be categorized as climatic and anthropogenic. The table below outlines some of these threats.

Table 5.3-2. Specific Threats to Biodiversity

Threats to Flora	Threats to Fauna
Overexploitation of vegetation	Poaching, as well as the insecurity of the agents of the protection of fauna
Overgrazing and trampling of the herbaceous layer by cattle	Overexploitation of resources by hunting and halieutics
Uncontrolled agro-pastoral practices	Genetic erosion through the abandonment of local breeds
Introduction of invasive species, which prevent the development of other species in the long run (water hyacinth)	Adoption of new breeds of larger size (sheep, goats, hens) to the detriment of local breeds
The itinerant culture that results in clearing new lands when old ones become less productive	The absence of domestic animal gene banks
Water pollution from pesticides that kill certain aquatic plants	Repression or disappearance of water fauna due to the reduction in the quantity of water
The excessive cutting of wood	Destruction of habitats
Genetic erosion following the abandonment of local varieties	Changing of the water levels, siltation
Changing of the water levels, siltation	Water pollution following the use of pesticides resulting in the death of certain aquatic species

Côte d'Ivoire

The Comoé National Park has seen significant biodiversity loss in recent decades, as is outlined in Table 5.3-2. The species that were the most widespread in the beginning experienced the most significant reductions, some greater than 90%. Some species such as the Cobe de Buffon and the Guib are water dependent and remain close to waterways. This has made them vulnerable to poachers who would usually set up camp at the edge of a river.

The majority of the species experienced losses greater than 75% in only 20 years. The Bubale, Hippotraque and Buffalo proved to be the exception, however. Their ability to survive could be related to the fact that they are less dependent on water than other species and this allowed them to better escape poachers.

Table 5.3-3. Estimation of the Population Change of the Ungulates in the Comoé National Park from 1978-1998 (according to Fischer, 1999)

Species	Years				Variation 1998/1978
	1978	1987	1995	1998	
Cobe de Buffon	50,000	55,700	9,400	4,400	-91%
Ourébi	26,000	31,000	4,300	2,200	-92%
Bubale	13,000	18,300	5,400	5,200	-60%
Céphalophe à flancs roux	15,000	5,500	5,200	1,600	-89%
Guib harnaché	10,000	3,100	2,600	900	-91%

Species	Years				Variation 1998/1978
	1978	1987	1995	1998	
Céphalophe bleu	6,000	900 ?	2,300	500	-92%
Phacochère	4,900	5,200	2,500	700	-86%
Céphalophe de Grimm	3,600	4,000	1,000	300	-92%
Buffalo	3,000	900 ?	8,200	4,600	+53%
Hippotrague	1,700	1,100	1,200	500	-71%
Cobe defassa	1,200	900	400	300	-75%
Total 11 species	134,400	126,600	42,500	21,200	-84%
Density per km²	11.7	11.0	3.7	1.8	

"Plan of installation of the National Park of Comoé and of development of its periphery 2002-2011".

Ghana

Several areas within the basin are becoming population nodes as people migrate from the rural areas to urban centres in search of a better livelihood and to escape tribal conflicts. The growth of settlements in areas of the basin, which are considered potential biodiversity conservation priority areas, particularly in the White Volta and Lower Volta basin, is of great concern. As a result of urban growth, habitats that could serve to conserve wildlife of international significance are being lost and this is leading to the decimation of biodiversity. Probably the greatest threat to biodiversity is water pollution arising from the urban wastewater. Most urban areas close to wetlands and discharge untreated or poorly treated domestic waste into these wetlands, thereby harming aquatic biodiversity. Interestingly, populations in areas within the basin that have been designated as protected areas have not experienced any significant change over the past decade.

Mali

In Seno, more than 90% of the lands are occupied by settlements or agriculture, leaving little room for biodiversity. Vegetation is sparse and reproduces with difficulty. Fauna are rare and are rapidly disappearing due to habitat loss and poaching. Aquatic species do not flourish due to the temporary nature of the surface water.

In Samori, however, there is strong biological diversity. The vast forests support a great many flora species. Avifauna dominates the forests, especially guinea fowls and ducks. Additionally, gazelles, hyenas, jackals, and hares can be found in the region. The Sourou River supports several fish species and is important habitat for hippopotamuses.

Togo

The uncontrolled practice of bushfires, deforestation, pollution, poaching, and the variations of river flows are resulting in the degradation of habitat and loss of biodiversity in Togo. Political and social upheaval in the early 1990s resulted in the invasion of national parks and reserves by neighboring populations. This caused significant destruction of the country's biodiversity.

h. Data and information gaps

Significant information, much of which can be found in Section 2.3, was provided on the endangered species in the basin, particularly terrestrial fauna. Little information was provided on aquatic species, however. Additionally, wetlands and aquatic habitats were either not discussed or were not elaborated upon. These areas will need to be expanded in the Final TDA.

5.4 Flooding

a. Status of the problem/issue

Flooding is another problem observed in the Volta River Basin. Extremely high rainfall rates and the creation of uncoordinated dams without appropriate management practices are normally blamed for the flooding. Land-use conversions can also exacerbate the problem. Soils with significantly reduced vegetation cover that are exposed to atmospheric elements have little infiltration capacities to reduce stormwater run-off. These floods affect the environment of the basin, but also cause significant loss of human life and economic loss.

See Figure 5.4-1 in Appendix D for a map of areas in the basin prone to flooding.

b. Transboundary elements

Flooding has a transboundary cause in the basin as it results from uncontrolled dam releases from the upper part of the basin, e.g., from Burkina Faso to Ghana on the White Volta, from Burkina Faso to Togo on the Oualé, and also from Burkina Faso to Mali on the Sorou River as the backwater effect from the management of the Léry dam.

Flooding also causes transboundary migration of people escaping rising waters.

c. Environmental impacts

Some of the environmental impacts of flooding include:

- Inundation of lands
- Erosion
- Loss of habitat
- Degradation of water quality

d. Socio-economic impacts

Where unforeseen flooding occurs, the socio-economic impacts can be devastating. Some of the impacts that have been observed in parts of the basin are:

- Loss of human life
- Loss of infrastructure
- Water-borne diseases
- Effects on human health
- Loss of agricultural productivity
- Migration
- Disruption of transportation infrastructure
- Increased poverty

e. Causal chain analysis

See Appendix B.

Major root causes include:

- Insufficient regional agreements on water
- Insufficient scientific capacity
- Low government priority on environment

- Abuse of power
- Poverty
- Insufficient economic incentives
- Inadequate technical infrastructure
- Insufficient knowledge/understanding
- Inadequate legal/regulatory basis
- Inadequate political will
- Inadequate institutions
- Insufficient government power
- Insufficient demonstration projects

f. Sectors and stakeholders

Some of the stakeholders include:

- Hydroelectric dam authorities
- Residents of the affected area

g. Supporting Data

Benin

The surface water causes the scouring of the lands already weakened by harmful cultivation methods (bushfire, misuse of manure, etc.) and collects in areas to form great marshy zones. These "dead" zones (Béréna in Wama language) serve as true obstacles to accessing neighboring areas and make roads impassable from July to October.

Additionally, these marshy zones are larval lodgings of various insects causing diseases such as malaria, river blindness, and diarrhea.

The large number of temporary rivers in the basin makes the practice of cultivating riverbeds possible. This is dangerous, however, as floods can come quickly from upstream. Lives and harvests have been lost as result of these practices.

Burkina Faso

Flooding occurs often in Burkina Faso. In recent years, the worst floods were experienced I 1988, 1992, 1994, and 1999. Only the provinces of Zondoma on Nakanbé are spared floods.

Table 5.4-1 Localization and Assessment of Floods In Burkina Faso

Year	Provinces	Localities	Persons Affected	Loss / Damage
1988	Bam	Sect. 4 and 6	966	Houses, Fields, and Poultry
	Bazega	T.Dassouri	993	
	Comoe	Banfora	1,192	
	Houet	Satiri	11,223	
	Kadiogo	Sect.8,17,	-	
	Kenedougou	22	1,443	
	Namentenga	N' Dorola	450	
	Oubritenga	Nagbingou	344	

Year	Provinces	Localities	Persons Affected	Loss / Damage
	Oudalan	Sect.1, 2,3,4	48	
	Seno	Gorom	514	
	Soum	Dori	300	
	Yatenga	Leri	1,953	
	Kossi	-	-	
	Kouritenga	Kouka	40	
	Mouhoun	Goughin	-	
	Tapoa	Bondokouy	1,500	
	Nahouri	Tenbaga	471	
	Sourou	14 Villages	137	
	Poni	Bomboro	150	
	Gourma	-	150	
	Ganzourgou	-	-	
	Sanmatenga	-	-	
		-		
	Bam	20 Localities	5,748	Houses, Fences, Wells, and Fields
	Bazega	02 Localities	1,938	Houses
	Boulgou	17 Localities	2,300	Houses and Fields
	Ganzourgou	05 Localities	1,340	Houses and Fields
1992	Gourma	03 Localities	825	Houses
	Oubritenga	09 Localities	11,713	Houses, Dams, and Cattle
	Sanmatenga	01 Localities	57	Houses and Fences
	Tapoa	02 Localities	59	Houses and Cattle
	Zoundweogo	02 Localities	86	Houses and Fields
	Bam	Sabcé	500	
	Sourou	Di	7,500	
	Seno	Dori	500	
	Kouritenga	Poutenga	2,500	
	Oudalan	Tinacof	560	
	Boulkiende	Siglé	200	
	Ganzourgou	Mobtédo	9,500	
	Namentenga	Boulsa	2,600	
	Boulgou	Bittou	2,200	
	Houet	Bama	450	
1994	Gourma	Fada	5,900	Houses, Fields, and Cattle
	Kossi	Konadougou	7,800	
	Mouhoun	Ouarkoye	2,500	
	Tapoa	Kantchari	10,800	
	Gnagna	Bogandé	500	
	Zoundweogo	Stuffed	121	
	Bazega	Sapné	4,510	
	Sanguie	Didyr	500	
	Sissili	Léo	1,500	
	Passore	Arbollé	-	
	Kenedougou	Djiguéra	40	

Year	Provinces	Localities	Persons Affected	Loss / Damage
	Nahouri	Pô	81	
	Bougouriba	Koper	201	
	Oubritenga	Loumbila	1,800	
1999	Kourwéogo	Toéghin	120	Houses, Fields, and Cattle
	Kadiogo	Sector 29	19	
	Houet	Bama	-	
	Nayala	Des Villages	-	
	Louroum	Des Villages	1,211	
	Oudalan	-	1,522	
	Oubritenga	-	130	
	Basle	-	-	
	Kossi	Des Secteurs	122 Households	
	Kenedougou	-	10 Families	
	Tuy	-	1324	
	Sanmatenga	Des Secteurs	-	
	Sourou	Sourou	-	
	Seno	Des Villages	-	
	Bam	Kiella	100	
	Banwa	Gossin	39,136	
	Mouhoun	Kassakongo	360	
	Passore	-	45	
	Ziro	-	220	
	Ioba	Des Villages	2,438	
	Bougouriba	Des Villages	136 Families	
	Nahouri	Des Villages	2,115	
	Tapoa	-	-	
	Konandjari	Des Secteurs	176	
	Gourma	Nagré	1,010	

Source: CONASUR

Ghana

Regional flood frequency curves have been approximately derived for the entire country of Ghana, but these were based on data from a limited period of time and data that are full of gaps (Ontoyin, 1985). In order to apply the Index-flood method, the country was divided into five provisional hydrologically homogenous regions based on rainfall, topography, and geology. The derived equations must be used with caution and the results should be treated as only provisional since they are primarily based on limited data. Only very few stations have continuous records of 20 years or more, giving rise to many inter-station correlation estimates.

Mali

Since 1989, the valley of Sourou has experienced unforeseen floods due to the management of the Léry Dam built in Burkina Faso. These floods often compromise harvests on the rice plantations.

Togo

Floods in Togo result from strong precipitation and from the release of water from the Kompienga Dam in Burkina Faso. Flooding results in the loss of human lives, destruction of infrastructure and property, and the outbreak of water-borne diseases. The damage recorded from the 1999 flood was evaluated at approximately $42 million.

h. Data and information gaps

More complete data on the frequency, severity, locations, causes, and consequences (both human and economic losses) of floods will need to be included in the Final TDA. This, however, will be hampered by the lack of historical data necessary to estimate floods, as was found to be the case with Ghana's flood frequency curves. Nonetheless, additional information will need to be provided in order to address the problem of flooding through appropriate interventions.

5.5 Water-Borne Diseases

a. Status of the problem/issue

Water-borne diseases have arisen in the basin largely as a result of the creation of dams and ponds and of flooding. The natural flow rates of the streams and rivers before impoundments are altered (slowed) to suit the breeding of the disease vectors at the banks of the rivers. Additionally, the proliferation of aquatic weeds exacerbates the problem of water-borne diseases as the weeds serve as hosts for disease-causing parasites.

Segments of the society in the basin suffer from a variety of diseases such as river blindness and sleeping sickness. Water-borne diseases affect economic activities as the workforce becomes ill and as parasites sometimes cause changes to occur in fish resources in sections of the rivers.

See Figure 5.5-1 in Appendix D for a map of areas where water-borne diseases are prevalent.

b. Transboundary elements

Water-borne diseases can be transboundary because of the movement and spread of disease vectors in the basin. Diseases have been eradicated in one part of the basin, only to be re-infected from another area of the basin. Additionally, water-borne diseases have been exacerbated by transboundary activities such as the damming of rivers.

c. Environmental impacts

- Possible damage to fish resources
- Possible decline in biodiversity

d. Socio-economic impacts

- Loss of human life
- Effects on human health
- Migration of populations to escape water-borne diseases
- Economic loss due to illness in workforce
- Increased poverty and disease

e. Causal chain analysis

See Appendix B.

Major root causes include:

- Inadequate legal/regulatory basis
- Insufficient scientific capacity
- Low government priority on environment
- Abuse of power
- Poverty
- Insufficient economic incentives
- Inadequate technical infrastructure
- Inadequate political will
- Insufficient demonstration projects
- Inadequate intersectoral coordination
- Insufficient knowledge/understanding
- Inadequate technology
- Inadequate training
- Population pressure

f. Sectors and stakeholders

Some of the stakeholders include:

- Basin population
- Public health authorities
- Local authorities

g. Supporting Data

Benin

No information provided.

Burkina Faso

Water-borne diseases are prevalent in Burkina Faso and have become more widespread as more dams have been built. 52% of medical consultations in Ouagadougou are a result of water – either water-borne diseases or illnesses relating to contaminated water – with malaria topping the list of reasons that people visit doctors in the region. Other diseases commonly found in the region include dracunculose and schistosomiases. Onchocercose and trypanosomiase are also found, but they are under better control.

Côte d'Ivoire

Water-borne diseases have a high human and economic cost in the Volta River Basin. Prevalent diseases include malaria, Bilharzia, Guinea worm, as well as a number of others. These diseases occur primarily when waters are stagnant and there is inadequate drainage or water treatment, largely due to inadequate investment in infrastructure. The diseases are generally localized in the cities and villages.

- Malaria is the primary cause of death (20%) with a frequency of 0.12/1000 persons.
- Diarrhea represented the second most common cause of death (15%) with a frequency of 18.1/1000.
- Guinea worm has a frequency of 0.9/1000.
- Ulcer of Buruli has a frequency of 0.24/1000.
- Bilharzia has a frequency of 0.225/1000.
- Onchocercose whose habitat is along the rivers has caused the abandonment of productive activities and depopulated border zones.

Ghana
All of the water-related diseases occurring in Ghana are prevalent in the Volta Basin. These include Bilharzia, which is very widespread in all four sub-basins, except the Daka. Other diseases include onchocerciasis (except in the Lower Volta), Guinea worm, malaria, filariasis, which is particularly common in the White Volta Basin, and diarrhea. Yaws has also been recorded in all five basins.

Table 5.5-1. Water-Borne and Associated Diseases and Their Vectors in the Volta Basin

	Schristo	Oncho	Guinea worm	Malaria	Filariasis	Cholera	Diarh	Yaws
Black Volta	+	+	+	+	?	?	+	+
White Volta	+	+	+	+	+	+	+	+
Daka	+	+	+	+	?	?	+	+
Oti	-	+	+	+	?	?	+	+
Lower Volta	+	-	+	+	+	?	+	+

Source: Nii Consult (1998)

\+ Diseases and vector recorded in area (1980-1996)
\- Disease vector not recorded
? No specific study undertaken

Mali
The access and use of the same water sources by humans and animals has resulted in a number of human health problems. As a result, water-borne diseases are prevalent in the region. Guinea worm, diarrhea, cholera, skin diseases, and other infections are widespread.

Togo
Togo also suffers enormously from water-borne diseases in the Volta River Basin.

h. Data and information gaps
While the types of water-borne diseases and their causes have been provided, only Cote d'Ivoire provided data on the number of people affected. Additional data should be provided on the geographic extent and the number of inhabitants infected in order to assess and address this issue. Further, two countries provided no data on this issue.

5.6 Growth of Aquatic Weeds

a. Status of the problem/issue

The growth of aquatic weeds has been noted as an increasing problem in the Volta River Basin. This has been of particular concern on some of the tributaries, especially on the Oti River. The weeds were probably inadvertently introduced into the basin as ornamental plants. A tributary of the Black Volta in Burkina Faso has also been infested with water hyacinth. The growth of the weeds has been exacerbated by the contamination of the waterways with fertilizers and other pollutants.

The effects of aquatic weeds on the environment include the rise in water-borne diseases, reduction in fish-catch, disruption of lake/river transportation, and disruption to hydropower generation.

See Figure 5.6-1 in Appendix D for a map of the areas affected by aquatic weeds in the basin.

b. Transboundary elements

The causes of aquatic weeds include introduction of alien weeds into the basin, transfer of watercrafts and fishing gear as a result of migration. Additionally, the run-off of fertilizers and nutrients from farmlands exacerbates the growth of the weeds.

In the Oti Basin, aquatic weeds are located in both Togo and Ghana and this could be a transboundary issue.

c. Environmental impacts

- Reduction in biodiversity
- Degradation of water quality
- Reduction of fisheries
- Increase in water lost through evapotranspiration

d. Socio-economic impacts

- Reduction in transport along the waterways
- Reduction in power-generating capabilities of hydroelectric plants
- Exacerbation of water-borne diseases
- Increased poverty through loss of income to fishermen

e. Causal chain analysis

See Appendix B.

Major root causes include:

- Insufficient knowledge/understanding
- Inadequate legal/regulatory basis
- Insufficient government power
- Inadequate institutions
- Insufficient regional agreements
- Abuse of power
- Poverty

- Insufficient economic incentives
- Inadequate technical infrastructure
- Inadequate political will

f. Sectors and stakeholders

Some of the stakeholders include:

- Basin population engaged in fishing
- Basin population engaged in transport
- Hydroelectric dam authorities
- Basin population affected by water-borne diseases

g. Supporting Data

The damming of the rivers in the Volta River Basin is viewed as a significant contributor to the proliferation of aquatic weeds. Several hydraulic structures have been erected along waterways within the basin. Notable among these are the Akosombo and Kpong hydropower dams, and the Vea and Tono reservoirs. These together have the potential to generate about 4,800 GWh/year of energy and some of this power is supplied to Togo and Benin. The reduction in flow rate due to the dams has promoted the proliferation of aquatic weeds in the Lower Volta. This has resulted in high incidence of bilharzia, as weeds provide sanctuary for snail hosts of schistosoma.

Although not many exotic species have been introduced into the basin, the accidental introduction of water hyacinth into the Oti River is quickly becoming a significant threat to the integrity of the hydropower dam at Akosombo. Within three years after the first report of the incidence of water hyacinth on the Oti, the weed had spread to cover more than an estimated 2,000 ha of lake surface. Control measures have cost more than 170 million cedis annually (approximately 20,000 USD). The presence of the weed is hampering lake transport and fishing. It may also be contributing to the siltation of the lake, as well as to the reduction in the water availability for hydropower generation.

Harmful aquatic plants have begun to develop in the waters near the Mali border with Burkina Faso as well. Although these are not yet a serious problem, they could become more of a threat in the future.

h. Data and information gaps

While the countries provided a map of areas where aquatic weeds were becoming prevalent, little additional data was given on the extent of the problem. The one exception was that information was given on the Oti River and the threats to Akosombo Dam. Further information on other areas should be given, however.

5.7 Coastal Erosion

a. Status of the problem/issue

Some coastal countries observed high coastal erosion, some as a probable result of creation of the Akosombo Dam with the attendant deficit of sediments reaching the coast.

See Figure 5.3-1 in Appendix D for a map of areas experiencing coastal erosion.

b. Transboundary elements

- Upstream dams are affecting the downstream coastline
- Several countries use the electricity generated from the Akosombo Dam, the prime contributor to coastal erosion
- Migratory species' habitat is being degraded

c. Environmental impacts

- Degradation of coastal habitats, including migratory bird habitats
- Destruction of sandy beaches used as nesting sites by endangered marine turtles
- Change in coastal waters
- Loss of productivity of waterways
- Reduction in biodiversity
- Degradation of water quality

d. Socio-economic impacts

- Loss of fish landing sites
- Loss of aesthetic value and tourism
- Loss of coastal resources
- Increased storm damage
- Loss or damage to human life or infrastructure

e. Causal chain analysis

See Appendix B.

Major root causes include:

- Insufficient scientific capacity
- Low government priority on environment
- Abuse of power
- Insufficient demonstration projects
- Poverty
- Inadequate political will

f. Sectors and stakeholders

Some of the stakeholders include:

- Coastal and river-side residents
- Population engaged in fishing in coastal waters
- Tourist industry

g. Supporting Data

Burkina Faso and Mali

These are inland countries and therefore have no coasts.

Côte d'Ivoire
Côte d'Ivoire has experienced substantial coastal recession. Up to 2 m/year has been recorded in Grand – Lahon, with degradation of historic sites. Around Abidjan, tourist infrastructures are threatened by erosion of 1.5 m/year (UNEP RSRS 1999). While erosion takes place naturally due to storms and swells, man-made construction and activities have greatly exacerbated the problem. The main anthropogenic factors are the construction of jetties to protect the Abidjan harbor and the Vridi Canal and coastal sand mining.

Ghana
Approximately 99% of sandy sediments are held back by the Akosombo Dam in the Volta Lake (Cheng, 1980). This contributes significantly to the erosion of the coastal areas at the mouth of the Volta River, ranging from 5 to 20 m per year (Blivi, 1993).

The construction of the Akosombo and Kpong dams has precipitated serious environmental problems. The regulated flow regime engendered by the operations of the dam caused a reduction in the hydrological thrust at the estuary, which tends to minimise the effect of wave action on the coast, and also constitutes a kind of hydrological groyne which breaks the force of wave action against the coast. The apparent decay of this groyne has also increased the rate of coastal erosion along the eastern side of the estuary. It is estimated that in the Keta area, the rate of coastal erosion is about 4 metres per year (Armah and Amlalo 1998). This coastal erosion has led to the destruction of nesting sites for endangered marine turtles.

Togo and Benin
The construction of large breakwaters for the Ports of Lome and Cotonou has caused extensive erosion, sometimes exceeding 150 m east of Lome. East of the Port of Cotonou, recession of more than 300-500m has been observed (UNEP RSRS 1999).

h. Data and information gaps
According to the limited data provided, only Ghana's coasts are affected by the Volta River. Additional information will need to be provided on the relationship between the Volta River and coastal erosion occurring in countries other than Ghana in order to establish this as a priority issue.

5.8 Water Quality Degradation

a. Status of the problem/issue
Although there is little data on the problem, water quality degradation has been identified as an important issue in the basin.

Some of the causes of water quality degradation include poor farming practices, improper land use, intensive grazing activities of cattle and sheep, and bushfires. Improper application of fertilizers to agricultural lands promotes leaching into the waterbodies. These chemicals are transferred downstream into other countries without any possible restriction. Sediment transport across the riparian countries is the major source of degradation of shared water resources.

Discharge from untreated industrial effluents are not significantly present in the basin due to limited industrial activities, but some untreated sewage is discharged into the waters. Additionally, humans and animals defecating and bathing in rivers and water sources adds to the degradation of water quality. Another significant cause of water quality degradation is the introduction of urban waste, particularly from run-off from inland port communities and urban settlements located near banks of the rivers and reservoirs.

b. Transboundary elements

Surface water resources are shared throughout the basin, making the degradation of water quality a strongly transboundary problem.

- Pollution is distributed throughout the waterways
- Land clearing in upstream countries has downstream effects

c. Environmental impacts

- Loss of biodiversity
- Loss of fisheries
- Harmful effects on coastal waters
- Occasional harmful algal blooms

d. Socio-economic impacts

- Scarcity of potable drinking water
- Scarcity of non-polluted water for agriculture and animal husbandry
- Effects on human health
- Water-borne diseases
- Loss of fisheries

e. Causal chain analysis

Water pollution originates from industry, crop farming, fishing, raising of livestock, and unsanitary conditions around human settlements.

The socio-economic root causes are poor control or supervision of industrial activities, poor farming practices including application of chemical fertilizers, poor awareness and education about public health, poor planning of settlements, population pressure and urbanization, lack of effective legal systems for controlling discharge of effluents and lack of financial resources.

See Appendix B.

Major root causes include:

- Insufficient regional agreements
- Inadequate legal/regulatory basis
- Insufficient knowledge/understanding
- Insufficient government power
- Inadequate institutions
- Abuse of power
- Poverty
- Inadequate national legal/regulatory basis

- Inadequate technology
- Inadequate training
- Population pressure
- Insufficient demonstration projects
- Inadequate intersectoral coordination
- Insufficient economic incentives
- Inadequate political will

f. Sectors and stakeholders

Some of the stakeholders associated with water quality degradation include:

- Basin population engaged in farming and animal husbandry
- Basin population engaged in fishing
- Basin population dependent on surface water resources for daily needs
- Industry

g. Supporting Data

Benin

Water pollution in the Volta Basin in Benin is derived primarily from human waste, from the use of fertilizers in agriculture, and from livestock breeding. The human and agricultural waste, along with soils, is washed or blown from the land into the tributaries of the Oti River (Sarga, Kounne, and Tirgou). This causes the siltation of the rivers, the destruction of aquatic fauna and its habitat, and the invasion of these rivers by aquatic weeds. This state of affairs decreases the biological river resources and constitutes a threat to the aquatic habitat.

Burkina Faso

According to the document "Etats de lieux des ressources en eau et de leur cadre de gestion", representative data on quality and quantity of water poses a problem. The limited data available, however, indicate the following:

Quality of Groundwater

Groundwater is in general potable. Ninety percent of the values are lower than the WHO recommendations for drinking water. There are areas in the southwest, though, where the acidity level of the water is not in conformity with WHO standards. Additionally, there are some areas in the southeast where 72% of samples have higher conductivity than WHO recommendations. Drilling in the area of Mogtédo (in the basin of Nakanbé) produced water with a high arsenic content, which was naturally contaminated by minerals rich in arsenic. The recorded maximum values are quite localized, however.

Quality of Surface Water

Only the ONEA (National office of Water and the Cleansing) has reliable data on surface water. Whereas the quality is declining in general, it continues to be generally of good physicochemical quality. Suspended matter is present throughout the basin, however, and significant quantities of iron and phosphates can be found in the water. Suspended matter is of particular concern in Nakambé, especially at the Loumbila, Poutytenga, and Ouagadougou dams. In all of the basins,

iron is the most alarming variable, followed by phosphates. The other parameters meet acceptable levels.

The bacteria and parasites in the water also pose a serious health risk. Bacteria often results from the proximity of cattle and human settlements to water sources. Eutrophication could not be evaluated using the limited available data, but the risk is evident in the growth of water hyacinth.

A number of industries in the basin emit waste into the waterways, with the agro-processing industry among these. The Brakina brewery emits water rich in detergents that sometimes has a pH of 11.6. The slaughterhouses (in Ougadougou and Bobo Dioulasso) dump solid waste including manure and blood into the waterways, as well as wastewater that is rich in grease, proteins, and phosphates. In 1997, the slaughterhouses of Ouagadougou consumed 48.7 million m^3 of water and produced approximately 10 tons of waste per day. Soap factories and oil mills emit solid waste and wastewater that is very basic.

There are also a number of industrial chemical facilities located primarily in Ouagadougou and Sore, including plants the produce plastics, cosmetics, drugs, paint, mattress foam, and matches. The most significant of these are Saphyto, Sofapil, Fasoplast, and Sap. Saphyto, producing pesticides and insecticides, emits chemicals into the atmosphere. Sofapil, producing dry cells, emits metals.

Textile and tanning factories in the basin also threaten water quality. The most prominent of these are Sofitex, SBMS, and Aliz, which are located in Ouagadougou, Sore, Koudougou, Dédougou, Fada Gourma and Houndé. The Sofitex factory emits significant amounts of air pollution. The leather manufacturer SBMC dumps 150 to 190 tons of chemicals annually without primary treatment. Effluents from the tanning company Aliz are contaminated with chemicals and proteins.

There are also two gold mines in the basin that affect water quality. Poura, an industrial mine, and Essakane, a semi-industrial mine, have resulted in the destruction of lands, the introduction of chemicals such as cyanide to the environment, and deforestation.

As agricultural production in Burkina Faso is still traditional, much less fertilizer and pesticides are used there than in developed countries, 8 kg/h as opposed to 240-250 kg/h.

Côte d'Ivoire

The water quality in Côte d'Ivoire is threatened by increasing urbanization and agriculture in the basin, as well as by pollution produced by households.

Ghana

Surface Water

The water quality of the major rivers within the Volta Basin is generally good for general purposes, although localized pollution occurs close to developed areas. On the Oti River, for example, mean pH values vary from 6.9 to 7.5 (WARM 1998). Mean suspended solid concentrations are generally less than 2000 mg/l. The dissolved oxygen concentrations generally indicate low levels of pollution since super saturation conditions are mostly noted. Values

ranged from 5.0 to 7.5mg/l. The waters are generally soft with total hardness not exceeding 25.0mg/l. Alkalinity, on the other hand, ranges from 19 to 52.0mg/l.

There are not many major industries in the Volta Basin, and those that do exist are generally small in scale. There are, however, two major textile factories in the basin. A fruit-processing factory, which processes tomatoes, also used to operate in the basin. These industries discharge their effluent, most of which is insufficiently treated, directly into water systems. Effluent quality from the Juapong factory is generally within EPA permissible standards, but has high BOD. The Akosombo factory's effluent contains high pH and a considerable amount of dye material. This could lead to the deterioration of water quality.

Table 5.8-1. Summary of Water Quality Parameters for Selected Rivers in the Volta Basin

Parameters	Suface Water Quality			
	White Volta (Dalon)	Black Volta (Bamboi)	Oti (Sabare)	Lower Volta (Sogakope)
Dissolved Oxygen (mg/l)	6.5	11.2	9.9	7.1
pH	7.1	7.0	7.0	7.3
Conductivity (µS/cm)	7.7	201	280	7.3
Total Dissolved Solids (mg/l)		87.2		59.2
Suspended solids (mg/l)	165			78
Alkalinity (mg/l)				39.8
Hardness (mg/l)				28.5
Silica (mg/l)		11.2		11.8
Nitrate-N (mg/l)	0.4			5.6
Phosphate-P (mg/l)	0.1			0.1
Chloride (mg/l)	17.5	7.0	5.4	10.4
Sulphate (mg/l)	19.9	7.0	5.7	2.7
Bicarbonate (mg/l)			35.3	46.2
Sodium (mg/l)	9.3			9.8
Potassium (mg/l)				2.8
Calcium (mg/l)	4.7	10.1	4.8	9.4
Magnesium (mg/l)	2.5	8.3	4.5	4.7
Iron (mg/l)				
Biochemical Oxygen Demand (mg/l)				4.0
Chemical Oxygen Demand (mg/l)	0.3			
Cadmium (mg/l)	0.03			<0.03
Lead (mg/l)	0.1			<0.03
Nickel (mg/l)				<0.03
Mercury (mg/l)				<0.03
Zinc (mg/l)	0.11			<0.03
Copper (mg/l)	0.11			<0.03
Total Coliforms (c/100ml)				
Faecal Coliforms (c/100ml)	16			18

Table 5.8-2. Summary of Water Quality at Kpong (1995)

Parameter	Mean	Std Dev.
PH	7.0	0.2
Temperature	28.2	1.4
Alkalinity	40.1	12.9
Total Hardness	21.6	3.4
Silica	10.6	6.0
Chloride	7.1	5.6
Sulphate	2.4	4.4
Calcium	7.5	4.0
Magnesium	2.1	1.1
Nitrate	0.2	0.4
Iron	0.1	0.1
Manganese	1.5	3.0
Suspended Solids	4.7	4.1

Groundwater

The quality of groundwater is generally good for multipurpose use, except for the presence of low pH (3.5-6.0) waters, high levels of iron, manganese, and fluoride in certain localities, as well as occasional high mineralisation with TDS in the range of 2000-1458 mg/l in the southeastern coastal aquifers.

Iron originates partially from the attack of low pH waters on corrosive pump parts and partly from the aquifers. The percentage of iron derived from the aquifers is, however, unknown. High fluoride values in the range 1.5-5.0mg/l, on the other hand, are found in boreholes located in the granitic formation of the Upper East and West Regions.

The waters in many hand-dug wells are turbid and polluted as they contain high levels of nitrate, in the range of (30-60) mg/l, and abundant coliform. This could be avoided to some extent through improved construction and adequate protection of the well sites from surface run-off and animal droppings.

Table 5.8-3. Summary of Water Quality Parameters for Groundwater in the Volta Basin

Parameters	Ground Water Quality	
	White Volta	Lower Volta
Dissolved Oxygen (mg/l)	-	-
PH	6.70	6.18 –6.96
Conductivity (µS/cm)	482	259 -2960
Total Dissolved Solids (mg/l)	-	233 - 1192
Suspended solids (mg/l)	-	-
Alkalinity (mg/l)	-	106 -1744
Hardness (mg/l)	-	146 - 303
Silica (mg/l)	29.1	32 - 485

Parameters	Ground Water Quality	
	White Volta	Lower Volta
Nitrate-N (mg/l)	2.91	2.6 –19.0
Phosphate-P (mg/l)	0.21	1.0 -0.37
Chloride (mg/l)	3.6	98 – 981
Sulphate (mg/l)	2.5	10 - 96
Bicarbonate (mg/l)	179	94.0 – 148.0
Sodium (mg/l)	22.0	30.0 – 431.0
Potassium (mg/l)	1.7	5.0 – 19.0
Calcium (mg/l)	31.74	30.0 –122.0
Magnesium (mg/l)	10.97	9.0 – 63.0
Iron (mg/l)	0 -	0 –5.0
Biochemical Oxygen Demand (mg/l)		
Chemical Oxygen Demand (mg/l)		
Cadmium (mg/l)	0.16	<0.03
Lead (mg/l)	0.0003	<0.03
Nickel (mg/l)	0.0014	<0.03
Mercury (mg/l)	0.0018	<0.03
Zinc (mg/l)	0.04	<0.03
Copper (mg/l)	0.001	<0.03
Total Coliforms (c/100ml)	11	8
Fecal Coliforms (c/100ml)	0	0

Mali

Water in Mali is polluted from human, livestock, and agricultural waste. Fungicides, pesticides, and fertilizers are increasingly being used in the region and are being washed into waterways during the rainy season. Some prohibited and extremely detrimental chemicals, such as DDT, are even being used in the area, though exact data are missing. Limited data available on the Souron River show:

- PH : >8,2
- Turbidity : 40
- Incubation à 44^{o}C : No fecal coliforms,
- Incubation à 37^{o}C : numerous total coliforms, bacillus bacteria (both gram positive and negative)

Nitrates are frequently found in subsoil waters, but at levels below WHO standards for water consumption. Iron has been found at levels above WHO standards. In general, water quality is neutral to basic.

Togo

While data on water quality are insufficient, it is known that surface water quality in Togo has been degraded by a number of anthropogenic activities taking place in the Volta River Basin.

Water pollution in Togo comes from three sources: industry, agriculture, and transport. Industrial pollution can be found in the area of Kara where oils leak from the power station and the Brewery of Benin discharges its waste into the surrounding brooks. In other cities in the basin, garages and mechanical workshop leak oils into the rivers.

Agricultural practices used in riverbeds further pollute the waterways. Fertilizers and other chemicals used on the crops are washed into the waterways. The growing of cotton increases this threat as even greater amounts of artificial fertilizers and pesticides must be used to grow this crop than are needed for others.

The old automobiles that are used in the Volta Basin add to the pollution of the waterways. The trucks and cars emit significant amounts of particulate matter that are washed into the rivers.

Domestic and solid wastes further contribute to water quality degradation in the basin. Inhabitants of rural areas typically defecate outdoors, and often do so near water sources (wells, rivers, or reservoirs). At the same time, people use the rivers and waterways for bathing. Additionally, household garbage is usually not disposed of properly and often ends up in waterways. Urban areas do not have adequate wastewater treatment facilities.

While the data in the tables below on water quality in the Kara River show that organic matter, nitrites, and nitrates are not too high, there is a definite bacteriological problem.

Table 5.8-4. Physio-chemical Analysis of the Waters of the Kara River in Togo

N°	Date	Origin	Color	Suspended matter mg/1	Putrescibility 5 days	M.O. KMn 04 mg/1	PH	Nitrites mg/1	Nitrates mg/1	Comments
K2	28/12/88	Toundè	Clear		-	13,1	7,2	traces	5,3	
K3	"	Niveau nouveau pont	«		-	12,8	6,8	0,58	6,0	TogoElectricité
K4	"	Q. COFAC	«		-	10,3	6,8	0	1,2	
K5	"	Ancien pont	«	-	-	11,1	6,5	Traces	6,1	Amont
K6	"	«	«	-	-	10,6	6,7	0,3	1,32	Aval
K7	"	Q. Bataskom	«	-	-	10,1	7,1	traces	2,3	

Source :SOTED,1989 Etude pour l'Amélioration du cadre de vie de la population au Togo

Table 5.8-5. Physio-chemical Analysis from the Waters of the Brewery of Benin of Kara

N°	Date	Origin	Color	Suspended matter mg/1	Putrescibility 5 days	M.O. KMn 04 Mg/1	PH	Nitrites	Nitrates	Comments
B1	28/12/88	Decanted water	White	1250	++++	132	9.52	30.21	133.8	Very degraded
B2	„	After neutralization	White	1035	++	102.5	8.05	28.02	124.1	Degraded
B3	„	After aeration	Yellow	1215	+	14.9	8.03	0.00	Traces	Degraded
K1	„	Water from Kpiyinboa	Light yellow	1200	-	10.2	7.91	0.10	0.44	-

Source :SOTED,1989 Etude pour l'Amélioration du cadre de vie de la population au Togo

Table 5.8-6. Results of the Bacteriological Analysis of the Waters of the Kara River

N°	Date	Origin	Total Numbers	MPN coliformes	MPN E. Coli	MPS Str. fécaux	Nbre Sulf-red /ml	Salmonella	Nitrates	Comments
K2	28/12/88	Tomdè	2,500,000	250	90	8	50	+		Amoebae
K3	"	Niveau nouveau pont /(C E E T)	1,750,000	600	50	70	12	0		Giardia algues
K4	"	Quartier COFAC	3,250,000	900	60	0	25	+		-
K5	"	Amont ancien pont	2,000,000	1200	0	0	20	0		-
K6	"	Aval ancien pont	500,000	2000	5	12	30	0		Giardia
K7	"	Quartier Batascom	3,500,000	600	120	50	0	0		Giardia Amoebae

Source :SOTED,1989 Etude pour l'Amélioration du cadre de vie de la population au Togo

Table 5.8-7. Amount of Chemical Products Used in the Volta Basin in Togo

					Manure			
	Insecticides	Fungicides	Herbicides	Fumigants	Urée (Kg)	NPK (Kg)	NPKSB (Kg)	Super Triple
Savannah Region	165.138	-	10	-	848.550	1.204.150	7.270.050	-
Kara Region	119.527	-	295	-	304.634	757.750	4.379.550	-
Sotouboua	38.950	-	-	-				
(canton Fazao)	144							
Plateau Region	132.326	-	-	-	956.870	179.500	3.571.400	-

					Manure			
	Insecticides	**Fungicides**	**Herbicides**	**Fumigants**	**Urée (Kg)**	**NPK (Kg)**	**NPKSB (Kg)**	**Super Triple**
Wawa	10.545	-	-	-	85.050	-	277.700	-
Kloto	24.617	-	-	-	353.450	-	950.870	-
Dayes	-	-	-	-	-	-	-	-
Blitta (Adélé)	35.871	-	-	-	123.300	-	845.000	-
Agou	7.368	-	-	-	77.500	-	293.550	-
Total	**534.531**		**305**		**2.750.357**	**2.141.400**	**17.588.120**	

h. Data and information gaps

Sufficient data to accurately assess the status of water quality in the basin were not provided. Limited data were given by Ghana and Togo on the effects of industry on water quality, but additional information needs to be included from all countries on the fecal coliform levels and degradation resulting from agriculture. More information should also be given on potential contaminant loads, such as the amount fertilizers and pesticides used in the basin. Additionally, eutrophication needs to be examined.

5.9 Emerging Issues

5.9.1 Urbanization

Problems associated with urbanization relate to increasing populations, including overall national population growth migration into urban areas. These changes will have significant consequences for waste management and the threat of degradation and scarcity of water supplies.

5.9.2 Increase in Industrial and Mining Activities

While industrial development has been slow in the Volta River Basin, it will continue to increase, particularly as the population expands. This industrial growth can be expected to produce potential new point sources of pollution that will have impacts on land and water resources in the basin. Mining activities in the basin, although currently relatively small in scale, could expand and pose an even greater threat to the environment than they currently do.

The rising population growth and increasing industrial development raise the demand for hydroelectric power. The general tendency in the region will be to continue impounding river basins for electricity generation. This threatens future availability of water resources, as well as the coastline of Ghana.

6.0 Stakeholder Analysis

TDA Guidance Documents recommend a stakeholder analysis be performed in support of the TDA, including "a description of all the stakeholders, including institutions, organizations, ministries, agencies, and industry related to the perceived issues should also be incorporated. The information pertaining to this list would include the effect of the issue on stakeholders, the nature and effectiveness of the interactions between the stakeholders as well as their strengths and weaknesses in view of their actual and/or potential role in managing water and water dependent resources."

Identification of the stakeholders and stakeholder groups provides a unique level of analysis of those most profoundly affected by environmental issues in the Volta River Basin. During the course of the project, a full stakeholder analysis should be undertaken following the Agenda 21 guidelines.

The National Reports revealed the following major stakeholders of the identified problems:

6.1 Land Degradation

Benin

- Ministry of Environment, Settlements and Urban Development
- Ministry of Agriculture, Livestock and Fishing
- Ministry of Interior and Security and Decentralization
- Ministry of Higher Education and Scientific Research
- Green Space NGO
- Protection of the Environment and Struggle Against Illiteracy (PELCA BENIN)
- RE/PAT – ONG
- TIM-TIM ONG
- ODEX

Burkina Faso

- Ministry of Environment and Water
- Department of Agriculture
- Ministry in Charge of Animal Husbandry
- Department of Administration of Territories/Lands
- The regional and provincial councils of regional planning
- PNGT The National Programme of Management of the Soils
- National Waters and Sanitation Office (ONEA)
- Burkina National Electricity Company (SONABEL)
- Valleys Development Authority (AMVS, MOB)

Côte d'Ivoire

- Ministry of Water and Forests
- Ministry of Agriculture and Animal Resources
- Ministry of Environment and Life

- Ministry of Interior and Decentralization
- Professional agricultural organizations, CIDT and ANADER.

Ghana

- Ministry of Interior/Ghana National Fire Service
- Ministry of Works and Housing/Water Resources Commission
- Ministry of Environment and Science/Environmental Protection Agency
- Ministry of Food and Agriculture/Irrigation Development Authority
- Ministry of Environment and Science/Water Research Institute of CSIR
- Ministry of Lands and Forestry/Forestry Commission
- The Lands Commission established by Act 483 of 1994
- Land Valuation Board
- Survey Department
- Land Title Registry
- Ministry of Local Governments

Mali

- Ministry in Charge of Agriculture
- Ministry in Charge of Livestock
- Ministry in Charge of Environment
- Ministry in Charge of Territorial Administration
- Ministry in Charge of Planning
- Ministry in Charge of International Cooperation

Togo

- Women are particularly involved in the management of land, particularly with regards to the use of land for subsistence agriculture, as women have the ultimate responsibility to nourish their children.
- Village Committees of Development (VCD) address the issue of development in the rural areas, including environmental questions.
- Ministry of the Interior, Security and Decentralization
- Ministry of Equipment, Mines, Energy, Post and Telecommunication
- Ministry of Environment and Forest Resources/Department of General Ecology and Rehabilitation of the Environment
- Ministry of Agriculture, Animal Husbandry and Fishing

6.2 Water Scarcity

Benin

- Ministry of Agriculture, Livestock and Fishing
- Ministry of Mines, Energy and Hydraulics
- Ministry of Public Health
- Ministry of Interior and Security and Decentralization
- Ministry of Higher Education and Scientific Research
- Ministry of Finance and Economy

- Protection of the Environment and Struggle Against Illiteracy (PELCA BENIN)

Burkina Faso

- Ministry of the Environment and Water
- Department of Energy and Mines
- Department of Agriculture
- Ministry in Charge of Animal Resources
- Department of Public Health
- Department of Transport and Tourism
- Department of Social Action and the Family
- National Water and Sanitation Office (ONEA)
- The regional and provincial councils of regional planning
- Green Cross International
- Burkina National Electricity Company (SONABEL)
- Valleys Development Authority (AMVS, MOB)
- Producers (Assocation)

Côte d'Ivoire

- Ministry of Water and Forests
- Ministry of Economic Infrastructure
- Ministry of Agriculture and Animal Resources
- Ministry of Mines and Energy
- Ministry of Environment and Life
- Ministry of Economy and Finances
- SODECI, Water Distribution Corporation, is responsible for supplying potable water to urban communities.

Ghana

- Ministry of Works and Housing/Water Resources Commission
- Ministry of Works and Housing/Community Water and Sanitation
- Ministry of Works and Housing/Hydrological Services Division
- Ministry of Environment and Science/Environmental Protection Agency
- Ministry of Food and Agriculture/Irrigation Development Authority
- Ministry of Environment and Science/Water Research Institute of CSIR
- Ministry of Mines/Public Utilities Regulatory Commission
- Ministry of Energy/Volta River Authority
- Ministry of Roads and Transport/Meteorological Services Department

Mali

- Ministry in Charge of Hydraulics
- Ministry in Charge of International Cooperation
- Ministry in Charge of Public Health
- Ministry in Charge of Livestock
- Ministry in Charge of Agriculture

- Ministry in Charge of Environment
- Women are the primary users of water for domestic needs.
- Regional and Local Water Councils
- Committees of Basin or Sub-Basin

Togo

- Women are very involved in the management of water resources. They are involved in drawing up water for domestic consumption and for agricultural production. When water is scarce, it is the task of women to traverse long distances in order to find water.
- Village Committees of Development (VCD) address the issue of development in the rural areas, including environmental questions.
- Ministry of Equipment, Mines and Hydraulic Resources/General Department of Hydraulics
- Ministry of Public Health
- Ministry of Environment and Forest Resources
- Ministry of Agriculture, Animal Husbandry and Fishing
- Ministry of Interior, Security, and Decentralization

6.3 Loss of Biodiversity

Benin

- Ministry of Environment, Settlements and Urban Development
- Ministry of Agriculture, Livestock and Fishing
- Ministry of Interior and Security and Decentralization
- Green Space NGO

Burkina Faso

- Ministry of Environment and Water
- Ministry of Agriculture
- Ministry in Charge of Animal Husbandry
- Department of Public Works, Settlements and Urban Development
- The regional and provincial councils of regional planning

Côte d'Ivoire

- Ministry of Water and Forests
- Ministry of Agriculture and Animal Resources
- Ministry of Environment and Life

Ghana

- Ministry of Environment and Science/Environmental Protection Agency
- Ministry of Lands and Forestry/Forestry Commission
- Ministry of Mines/Mineral Commission
- Ministry of Food and Agriculture

Mali

- Ministry in Charge of Environment
- Ministry in Charge of Agriculture
- Ministry in Charge of Livestock
- Ministry in Charge of Territorial Administration
- Ministry in Charge of Planning
- Women are primarily responsible for deforestation for firewood

Togo

- Women are the primary users of firewood and charcoal so they play an important role in the management of forests.
- Ministry of Environment and Forest Resources
- Ministry of Agriculture, Animal Husbandry and Fishing

6.4 Flooding

Benin

- Ministry of Environment, Settlements and Urban Development
- Ministry of Public Health
- Ministry of Mines, Energy and Hydraulics
- Ministry of Interior and Security and Decentralization

Burkina Faso

- Ministry of Environment and Water
- Department of Energy and Mines
- Department of Public Health
- Department of Transport and Tourism
- National Water and Sanitation Office (ONEA)

Côte d'Ivoire

- Ministry of Water and Forests
- Ministry of Economic Infrastructure
- Ministry of Mines and Energy
- Ministry of Transport
- Ministry of Environment and Life
- Ministry of Economy and Finances
- Ministry of Public Health

Ghana

- Ministry of Works and Housing/Water Resources Commission
- Ministry of Works and Housing/Hydrological Service Department
- National Disaster Management Organisation
- Ministry of Environment and Science/Environmental Protection Agency
- Ministry of Energy/Volta River Authority
- Ministry of Food and Agriculture/Irrigation Development Authority

- Ministry of Environment and Science/Water Research Institute of CSIR
- Ministry of Local Governments

Mali

- Ministry in Charge of Hydraulics
- Ministry in Charge of Environment
- Ministry in Charge of Agriculture

Togo

- The National Committee of Emergency Assistance was created in 1995 to address catastrophes such as floods. In 1997 the committee drafted a plan of Organization of Assistance in the Event of Catastrophes (Plan ORSEC). This committee is placed under the supervision of the Ministry for the Interior and Decentralization.
- Ministry of Equipment, Mines and Hydraulic Resources
- Ministry of Public Health
- Ministry of Environment and Forest Resources
- Ministry of Agriculture, Animal Husbandry and Fishing
- Ministry of Cooperation and Foreign Affairs

6.5 Water-Borne Diseases

Benin

- Ministry of Environment, Settlements and Urban Development
- Ministry of Public Health
- Association for the Social Integration of Poor Children (AISED)

Burkina Faso

- Department of Public Health
- Department of Transport and Tourism
- Department of Social Action and the Family
- National Water and Sanitation Office (ONEA)

Côte d'Ivoire

- Ministry of Water and Forests
- Ministry of Environment and Life
- Ministry of Public Health

Ghana

- Ministry of Environment and Sciences/Environmental Protection Agency
- Volta River Authority
- University of Ghana/Nogouchi Memorial Institute for Medical Research
- Ministry of Local Governments

Mali

- Ministry in Charge of Environment
- Ministry in Charge of Public Health

Togo

- Ministry of Public Health
- Ministry of Equipment, Mines and Hydraulic Resources
- Ministry of Agriculture, Animal Husbandry and Fishing
- Ministry of Environment and Forest Resources
- Ministry of Social Affairs and Promotion of Women

6.6 Growth of Aquatic Weeds

Benin

- Ministry of Environment, Settlements and Urban Development
- Ministry of Agriculture, Livestock and Fishing
- Ministry of Mines, Energy and Hydraulics
- Ministry of Interior and Security and Decentralization

Burkina Faso

- Department of Energy and Mines
- Ministry of Environment and Water
- Department of Transport and Tourism
- National and Water Sanitation Office (ONEA)

Côte d'Ivoire

- Ministry of Water and Forests
- Ministry of Mines and Energy
- Ministry of Transport
- Ministry of Agriculture and Animal Resources
- Ministry of Public Health

Ghana

- Ministry of Environment and Science/Environmental Protection Agency
- Ministry of Energy/Volta River Authority
- University of Ghana/Department of Zoology
- Ministry of Works and Housing/Hydrological Services Department
- Ministry of Environment and Science/Water Research Institute
- Water Resources Commission

Mali

- Ministry in Charge of Hydraulics
- Ministry in Charge of Environment

Togo

- Ministry of Equipment, Mines and Hydraulic Resources
- Ministry of Agriculture, Animal Husbandry and Fishing
- Ministry of Environment and Forest Resources

6.7 Coastal Erosion

Benin

- Ministry of Environment, Settlements and Urban Development
- Ministry of Agriculture, Livestock and Fishing

Burkina Faso

- Ministry of Environment and Water
- Department of Administration of Territories/Lands

Côte d'Ivoire

- Ministry of Environment and Life
- Ministry of Tourism

Ghana

- Ministry of Environment and Science/Environmental Protection Agency

Mali

Togo

- Ministry of Equipment, Mines and Hydraulic Resources
- Ministry of Agriculture, Animal Husbandry and Fishing
- Ministry of Environment and Forest Resources
- University of Lome

6.8 Water Quality Degradation

Benin

- Ministry of Environment, Settlements and Urban Development
- Ministry of Agriculture, Livestock and Fishing
- Ministry of Public Health
- Ministry of Interior and Security and Decentralization
- Association for the Social Integration of Poor Children (AISED)

Burkina Faso

- Ministry of Environment and Water
- Department of Agriculture
- Department of Public Health
- Department of Transport and Tourism
- Department of Social Action and the Family

- National Water and Sanitation Office (ONEA)

Côte d'Ivoire

- Ministry of Water and Forests
- Ministry of Economic Infrastructure
- Ministry of Agriculture and Animal Resources
- Ministry of Environment and Life
- Ministry of Economy and Finances
- Ministry of Public Health

Ghana

- Ministry of Works and Housing/Water Resources Commission
- Ministry of Environment and Science/Environmental Protection Agency
- Ministry of Mines/Public Utilities Regulatory Commission
- Ministry of Food and Agriculture/Irrigation Development Authority
- Ministry of Works and Housing/Ghana Water Company, Ltd.
- Ministry of Works and Housing/Community Water and Sanitation
- Ministry of Environment and Science/Water Research Institute of CSIR
- Ministry of Local Governments

Mali

- Ministry in Charge of Hydraulics
- Ministry in Charge of Environment
- Ministry in Charge of Public Health
- Ministry in Charge of Agriculture
- Ministry in Charge of Livestock

Togo

- Village Committees of Development (VCD) address the issue of development in the rural areas, including environmental questions.
- Ministry of Public Health
- Ministry of Equipment, Mines and Hydraulic Resources
- Ministry of Agriculture, Animal Husbandry and Fishing
- Ministry of Environment and Forest Resources

In addition, common Stakeholders for nearly all of these problems are:

- Women
- Children
- Inhabitants
- Resource users
- Academia

7.0 Environmental Quality Objectives

This section describes the major interventions and actions that are technical inputs for consideration by the six riparian countries as they develop and agree upon their Strategic Action Programme. These interventions were developed using Environmental Quality Objectives as tools, which were then assigned specific targets that were achievable over a 5-10 year period. Specific interventions and actions that would lead to achievement of these targets were identified.

The use of EQOs, targets, and interventions is consistent with the GEF approach for TDAs, although framed in a slightly different fashion. The EQOs are broad, policy-level statements of the desired condition of the Volta River Basin environment. Targets are specific, time-dependent and quantifiable steps towards achieving the EQOs. Finally, interventions or activities represent a list of steps necessary to achieve the target in the time frame and at the level specified. Consistent with GEF guidance, each Target and each Intervention/Activity is assigned an environmental indicator. GEF specifies three types of indicators, as follows:

Process Indicator
A step/activity which provides for future environmental improvements, but actually does not deliver any, e.g.:

- TDA
- NCAP/SAP
- Convention agreed, ratified, and comes into force
- Public awareness increases

Stress Reduction Indicator
A step/activity that actually reduces stress on the environment, e.g.:

- Municipal wastewater treatment plant built and operating
- Buffer zones created around river banks
- Farmers reduce use of fertilizer or pesticides
- Protected areas established and functional
- ICZM plan implemented
- Fishing quotas obeyed and/or enforced

Environment Status Indicator
An environmental parameter whose level can actually be measured to show improvement (or not), e.g.:

- Overall level of biodiversity increases
- Endangered/threatened species taken off list
- Fisheries yield stable or increasing and sustainable
- Concentration of pollutants in the Sea or basin river water or sediments decreases

The use of environmental indicators is a means to specify *a priori* the expected output or result of that activity or intervention. Therefore, activities such as new laws or regulations may represent a process indicator, improved industrial processes resulting from the new laws and regulations represent a Stress Reduction Indicator, and reduced levels of contaminants in the Volta River will represent an Environmental Status Indicator. Similarly, the targets can be classified by a series of environmental indicators.

Therefore, the use of EQOs and Targets is simply a novel step taken to develop an expert consensus on priority interventions/actions, complete with environmental indicators, as a step towards creation of the NCAPs and SAP.

7.1 Environmental Quality Objectives for the Volta River Basin

One of the final goals of the TDA is to identify possible interventions to address the major perceived issues through the root causes. Numerous possible interventions have been identified in the various National Reports. Lacking a framework to organize these interventions, and to facilitate their ranking and ordering, the concept of environmental quality objectives was used.

The three EQOs and their associated targets for the TDA /SAP process are:

1. Balanced aquatic ecosystem
   - Achieve adequate surface water quality by 2012
   - Restore natural surface water flow by 2012
   - Achieve sustainable fisheries development by 2012
   - Arrest wetland loss by 2012
   - Begin implementation of riverine biodiversity conservation strategy by 2008

2. Stabilized high-quality freshwater supplies
   - Achieve adequate freshwater quantity by 2012
   - Achieve adequate groundwater quality and quantity by 2012

3. Sustainable land use
   - Reduce rate of land degradation by 20% 2012
   - Reduce coastal erosion rates by 25% by 2012

7.2 Action Areas and Possible Specific Actions

Targets for each of the EQOs were identified. In addition, specific actions/ interventions were also determined.

Table 7.2-1 outlines targets, specific actions/interventions, and estimated costs identified. This table also categorizes the intervention by type. Categories of intervention were defined as:

- Legal / Regulatory
- Baseline investment
- Incremental investment

- Institutional strengthening
- Policy
- Scientific investigation
- Capacity building
- Data management

Although some actions / interventions may span several categories, the dominant category was selected as representative. In some cases, a single action / intervention was assigned to two categories, when no dominant type was apparent.

Table 7.2-1. Environmental Quality Objectives, Targets, and Interventions

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
Balanced Aquatic Ecosystem	Achieve adequate surface water quality by 2012	Establish common methods for assessing water and sediment quality, including bioassays of coastal biota	Develop guidelines for methods of water, sediment, and biota monitoring and assessment (including sampling, analysis, risk assessment)	Legislative/ Regulatory	Insufficient scientific capacity
			Implement a first periodic assessment (3-year interval) of the river quality and trends	Investment	
			Develop and establish national/regional land-based activities data and information management system as a tool for contaminant assessment and management	Data Management	
		Fill gaps in knowledge of priority pollutants (contaminant levels) and major sources of pollutants (contaminant inputs)	Conduct regional assessment of priority land-based activities, sources of contaminants, and pollutant levels in water and sediments	Scientific Investigation	Insufficient scientific capacity
			Conduct routine targeted monitoring of riverine sediments and biota for purposes of identifying major hot spots of pollution and land-based activities	Investment	
		Exchange environmental data and information	Develop agreements and technology basis for the free and regular exchange of environmental data and information within the region	Data Management	Insufficient scientific capacity; Inadequate technical infrastructure
		Reduce impacts of urban areas on water quality	Construct or extend sewage collection systems in all major cities in the basin and route discharges to treatment plant	Investment	
			Upgrade/renovate existing treatment plants for mechanical and biological treatment	Investment	
			Expand solid waste collection in all major cities and improve disposal methods so waste does not run-off or leach into waterways	Investment	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
		Reduce impacts of industry and mining on water quality	Develop and enforce regulations on the disposal of industrial and mining effluents	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Inadequate institutions; Insufficient demonstration projects; Inadequate of technology
			Strengthen the capacity of institutions to enforce mining and industry regulations	Institutional Strengthening	
			Implement demonstration projects to bring best technology and practice to industrial discharges (e.g., pre-treatment, source control, process control)	Investment	
			Identify major pollutants affecting water quality, and regulatory levels for those pollutants	Scientific Investigation	
		Halt the spread of aquatic weeds by 2010	Improve knowledge of distribution of aquatic weeds using regional working groups	Scientific Investigation	Insufficient knowledge/ understanding; Inadequate legal/ regulatory basis; Inadequate river basin management
			Develop national and regional aquatic weed management strategies/plans/frameworks combined with monitoring and GIS capabilities	Policy	
			Establish and implement a control system for the import and export of exotic species into and from the Volta River Basin	Legislative/ Regulatory	
	Restore natural surface water flow by 2012	Improve water basin management	Agree regionally on extraction of river water and control of river flow regimes	Legislative/ Regulatory	Inadequate water basin management; Insufficient regional agreements; Inadequate intersectoral

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
					coordination
			Conduct baseline investigation to establish the minimum threshold required for ecosystem function.	Scientific Investiation	
			Manage water release from hydro-electric dams in accordance with natural requirements	Legislative/ Regulatory	
			Manage water usage for agriculture and other uses in order to maintain more natural river water level and prevent detrimental impact on the ecosystem	Legislative/ Regulatory	
			Develop a regional commission with appropriate policy/legal basis to monitor regional water quantity and quality	Policy	
			Implement regional EIA for water management projects, perhaps through the ESPOO Convention, to enhance broad stakeholder involvement in major water projects	Legislative/ Regulatory	
			Develop regional basin water management plan of action	Policy	
			Strengthen the capacity of institutions to implement regional basin water management plan of action.	Institutional Strengthening	
	Achieve sustainable fisheries development by 2012	Strengthen legal basis	Assure that legislation regulating fishing gear, quotas, size limits, seasons and allowed fishing areas are in place	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Insufficient scientific capacity; Insufficient regional agreements; Inadequate institutions
			Strengthen enforcement of quotas, size limits, seasons, etc., relying on community-based fishery management activities	Policy	
			Help harmonize fishing regulations amongst Volta River Basin countries	Policy	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Strengthen capacity of institutions to enforce fisheries regulations	Institutional Strengthening	
			Establish “no take zones” either geographically or seasonally	Legislative/ Regulatory	
			Establish criteria for “healthy” fisheries situation	Scientific Investigation	
		Develop site-specific or species-specific management plans that promote sustainable utilization and protect nursery or reproduction areas	Develop management plans, and implement and monitor them with local communities and user groups	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Insufficient economic incentives; Inadequate institutions
			Strengthen capacity of local communities to implement and monitor management plans	Institutional Strengthening	
		Provide alternative technologies	Develop and demonstrate mechanisms to reduce by-catch	Policy	Inadequate technology
	Arrest wetland loss by 2012	Fill gaps in knowledge of priorities in protecting wetlands	Undertake inventory of selected wetlands sites in the basin to establish extent and condition of habitat and management challenges	Scientific Investigation	Insufficient scientific capacity; Insufficient knowledge/ understanding
		Strengthen regional legal basis for protection of wetlands	Review, harmonize, and strengthen relevant local, national, regional, and international legislation and conventions relevant to the conservation and management of wetlands	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Insufficient regional agreements
		Develop management plans for selected wetlands sites of global and ecological importance by 2007	Develop national wetlands management strategies/ plans/ frameworks (including community participation and empowerment)	Policy	Inadequate legal/ regulatory basis; Inadequate human capacity; Inadequate institutions
			Strengthen the capacity of local conservation groups to conserve wetlands	Institutional Strengthening	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
	Begin implementation of riverine biodiversity conservation strategy by 2008	Develop and implement regional biodiversity strategy	Prepare a regional biodiversity strategy document, including a gap analysis, and obtain endorsement by riparian states	Policy	Insufficient regional agreements; Inadequate water basin management; Insufficient knowledge/ understanding
			Implement biodiversity strategy, including species specific action plans	Scientific Investigation/ Investment	
		Prevention of adverse human activity on sensitive areas	Evaluate sensitivity of areas and habitats in the Volta River Basin and evaluate levels of human impacts on them	Scientific Investigation	Insufficient knowledge/ understanding; Inadequate legal/ regulatory basis
			If necessary, develop legislation for the protection of areas not currently covered or included in protected zones	Legislative/ Regulatory	
			Develop and implement action plans for those sensitive areas where human impact is adverse	Investment	
		Reduce impacts of agriculture, land grazing, and hunting on loss of biodiversity	Implement alternatives to agricultural expansion, unchecked grazing, and poor hunting practices, including bushfires and poaching, to conserve biodiversity	Investment	Insufficient economic incentives
Stabilized high-quality freshwater supplies	Achieve adequate freshwater quantity by 2012	Rationing of water use through international agreements on shared water basins	Review and strengthen existing regional river system agreements; develop new agreements	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Insufficient knowledge/ understanding; Insufficient economic incentives; Inadequate water basin management

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Harmonize environmental and economic policy regarding water use	Policy	
			Monitor supply and quality of water in major rivers	Investment	
			Prepare environmental impact assessments (EIAs) for major investments that may affect water quantity or quality	Investment	
			Support freshwater resource tenure and valuation	Investment	
	Achieve adequate groundwater quality and quantity by 2012	Fill gaps in knowledge	Develop common guidelines for periodic assessment of groundwater quality and quantity trends	Scientific Investigations	Insufficient scientific capacity; Insufficient knowledge/ understanding
			Develop and implement a groundwater quality trend monitoring programme	Investment	
			Conduct the first periodic assessment of groundwater quality and its trends	Investment	
			Evaluate sustainable groundwater use rates, and appropriate monitoring systems	Scientific Investigations	
		Improve efficiency and availability of high-quality well water	Based on the sustainable groundwater use rates, improve water extraction and transport systems to rural and urban areas	Investment	Inadequate technical infrastructure; Insufficient economic incentives; Insufficient demonstration projects
			Institute a water use fee structure for all water users	Investment	
		Reduce evaporative losses in drainage basin	Rationalize the use of small dams and barrages for local communities	Policy	Inadequate technical infrastructure
			Revegetate (reforest, replant) the drainage basin to increase natural evapotranspiration processes	Investment	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
Sustainable land use	Reduce rate of land degradation by 20% by 2012	Strengthen regional legal basis for preventing land degradation	National review of policy, legal, and regulatory frameworks, and institutional structure for addressing land-based activities (including international conventions such as climate change)	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Insufficient regional agreements; Low government priority on environment
			Draft Regional EIA process review in a regional workshop; adopt regional EIA	Legislative/ Regulatory	
			Develop realistic National Plans of Action for land-based sources and activities	Capacity Building	
			Develop common regional guidelines containing appropriate recommendations for decision makers for management of land-based point and non-point pollutant sources	Scientific Investigation	
			Strengthen capacity of institutions to implement National Plans of Action and EIA process review	Institutional Strengthening	
		Strengthen monitoring capacity for evaluating land degradation rates	Develop a regional commission with appropriate policy/legal basis to monitor regional land degradation	Policy	Insufficient regional agreements; Inadequate training; Inadequate human capacity; Inadequate institutions
			Develop training and educational programs to train regional personnel on monitoring and use of GIS as a planning tool	Capacity Building	
			Develop regional and national institutions to perform ongoing monitoring of land degradation, including geographic areas, causes, and rates	Investment	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Involve stakeholders, including NGOs and natural resource users, by communicating the results of monitoring and communicating alternative strategies for resource use	Capacity Building	
		Determine and satisfy training needs in region for land-based activities and sources	Conduct survey on training needs and conduct training on land-based activities and sources (for high officials, mid-level government, community, resource users, experts, industry, etc.)	Capacity Building	Inadequate training; Inadequate human capacity
		Improve Stakeholder knowledge of causes of land degradation, and involve the stakeholders in its solution	Develop outreach and public awareness program regarding land degradation	Investment	Insufficient knowledge/ understanding
			Create community-based agent network to educate and advise stakeholders on alternatives to traditional, harmful activities causing land degradation	Investment	
		Develop educational programs at all levels on land-based activities and sources	Conduct survey on educational needs to support reduction of land-based activities and sources and implement the activities to address three top priority regional educational needs, in appropriate languages	Capacity Building	Insufficient knowledge/ understanding; Inadequate training; Inadequate technology
			Develop necessary training at different levels on public awareness, applying Best and Cost Effective Technology, Best Agricultural Practices, Integrated Pest Management, increasing irrigation efficiency and fertilizer use, etc.	Capacity Building	
		Develop Regional/ Governmental/ Private Sector partnerships on LB activities and sources	Integrate private sector into activities of this project, as appropriate, as sub-contractor, consultant, or co-sponsor of specific activities	Policy	Insufficient economic incentives
		Strengthen legal basis and institutional capacity to reduce impacts of agriculture and animal husbandry	Develop and enforce land use codes for agriculture and animal husbandry	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Inadequate institutions

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Strengthen institutional capacity to support rangeland management; develop community rangelands	Institutional Capacity	
		Develop programs to reduce impacts of agriculture and animal husbandry	Riparian countries agree to a list of banned agrochemicals and develop a program to destroy stored banned products	Legislative/ Regulatory	Insufficient regional agreements; Inadequate training; Inadequate legal/ regulatory basis; Inadequate technology; Insufficient scientific capacity
			Riparian countries agree on limits to the application of agrochemicals and develop strategies to encourage the sustainable use of organic manure fertilizer	Legislative/ Regulatory	
			Riparian countries agree on regional controls on bushfires for agriculture, pasturage, and hunting, and enforce the controls	Policy	
			Conduct training courses at farmer and industry level to apply the most appropriate and new findings in their practice by 2008	Capacity Building	
			Strengthen and enforce regulations on the disposal of animal waste	Legislative/ Regulatory	
			Develop more efficient ways to use existing land, increasing yields through better land management, crop rotation, or crop selection	Investment	
			Develop basin-wide corridors for seasonal migration of livestock through adjacent countries, based on historical common use zones	Policy	
			Develop community-based agricultural/ animal husbandry networks for transfer of technology and best practice	Institutional Strengthening	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Establish regional and national capacities to monitor, examine causes, and map (using GIS) geographic locations of agriculture and animal husbandry, including protection objectives. Broadly disseminate the results to rural inhabitants.	Investment	
		Establish and maintain a network of well-managed protected areas in the Volta River Basin	Establish a functioning regional protected area working group for protection and management functions, financial arrangements, recommending new protected areas and addressing management of protected areas located along international borders	Institutional Strengthening	Inadequate institutions; Insufficient regional agreements; Insufficient knowledge/ understanding; Inadequate legal/ regulatory basis; Insufficient economic incentives; Inadequate training; Insufficient scientific capacity
			Obtain government endorsement for the recommended protected areas	Policy	
			Evaluate the priority targets for protection in each protected area and how these fit into regional priorities	Scientific Investigation	
			Review and propose revisions for national legislation on protected areas to permit environmentally friendly uses of the protected areas	Legislative/ Regulatory	
			Allocate a zone within protected areas or adjacent to them for ecotourism activities	Legislative/ Regulatory	
			Provide training in national protected area management and development of ecotourism	Capacity Building	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Reduce poaching in protected areas by ensuring that legislation regulating hunting equipment, quotas, seasons and allowed hunting areas are in place and strengthening enforcement of these regulations	Legislative/ Regulatory	
			Increase stakeholder participation, including community ownership, of protected areas	Capacity Building	
			Establish regional and national capacities to monitor, examine causes, and map (using GIS) geographic locations of protected areas, including protection objectives. Broadly disseminate the results to rural inhabitants.	Investment	
		Reduce rates of deforestation	Identify main contributors to deforestation, including public and private sector, as well as legal and regulatory failures	Scientific Investigation	Insufficient demonstration projects Insufficient economic incentives; Insufficient knowledge/ understanding; Inadequate legal/ regulatory basis; Inadequate human capacity
			Identify alternative sources for products historically produced from forests, and link with appropriate incentives and disincentives	Scientific Investigation	
			Identify means to increase efficiency and reduce waste in use of forest products, through demonstration projects	Investment	
			Establish legislation to reduce rates of deforestation based on economic incentives and disincentives	Legislative/ Regulatory	
			Establish reforestation programs and begin their implementation in affected areas, at village, community, national, and regional levels	Investment	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Establish regional and national capacities to monitor, examine causes, and map (using GIS) rates and geographic locations of deforestation and reforestation. Broadly disseminate the results to rural inhabitants.	Investment	
		Reduce rates of loss of land to desertification	Increase awareness of local populations of the desertification process, perhaps working through existing mechanisms	Capacity Building	Insufficient knowledge/ understanding; Inadequate legal/ regulatory basis; Insufficient scientific capacity; Insufficient demonstration projects
			Improve legal basis in each country for combating desertification, including: criteria to define land degradation; amended laws on forestry, water resources and land; and, strengthened legal mechanisms such as EIA and planning procedures	Legislative/ Regulatory	
			Develop a desertification monitoring system and widely disseminate results	Capacity Building	
			Demonstrate ways to reverse desertification	Investment	
		Reduce land degradation due to mining	Evaluate national legislation addressing mining and use of non-living resources	Scientific Investigation	Inadequate legal/ regulatory basis; Inadequate intersectoral coordination; Insufficient regional agreements; Insufficient demonstration projects

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Create regional working group on land degradation due to mining, and recommend specific common regional improvements to policy and legislation	Policy	
			Implement recommendations of regional working group in national laws and regulations	Legislative/ Regulatory	
			Perform demonstration projects of ways to avoid adverse environmental impacts of mining	Investment	
		Develop culturally-adapted improvements to land tenure systems/property rights in the region	Perform investigation of the policy, legal, and cultural basis for land tenure policies in the Volta River Basin	Scientific Investigation	Inadequate legal/ regulatory basis; Insufficient economic incentives
			Develop more effective methods of land tenure to reduce tendency for migration to fresh lands, and to encourage "investment" in lands (e.g., efficient irrigation, improved crop methods)	Policy	
			Implement environmentally sustainable land tenure systems in the region, perhaps as a "special planning zone"	Investment	
	Reduce coastal erosion rates by 25% by 2012	Fill gaps in knowledge	Conduct assessment of the effects of Akosombo Dam on coastal erosion on the Gulf of Guinea coast	Scientific Investigation	Insufficient knowledge/ understanding
		Develop coastal erosion management plan through a participatory process	Promote environmental and community-based tourism	Capacity Building	Insufficient economic incentives; inadequate human capacity
		Strengthen legal basis for protection of coastline	Review, harmonize and strengthen relevant local and national policies and legislation regarding coastal zone and river basin management	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Inadequate intersectoral coordination

Appendix A

List of Abbreviations

ACOPS	Advisory Committee on Protection of the Sea
BOD	Biological Oxygen Demand
CAF	Center for Africa Wetlands
CILSS	Comité Permanent Inter Etats de Lutte Contre la Sécheresse
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DANIDA	Danish International Development Agency
ECOWAS	Economic Community of West African States
EPA	Environmental Protection Agency
EQO	Environmental Quality Objective
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEPRENAF	Project for the Participative Management of Natural Resources and Fauna
GNP	Gross National Product
GWL	Groundwater Laterite
GWP/WATAC	Global Water Partnership/West African Technical Advisory Committee
ICARM	Integrated Coastal Area and River Basin Management
ITCZ	Inter-Tropical Coverage Zone
IUCN	The World Conservation Union
LOICZ	Land-Ocean Interactions in the Coastal Zones
MPPI	Major Perceived Problem and Issue
NAP	National Action Plan
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organization
SAP	Strategic Action Programme
TDA	Transboundary Diagnostic Analysis
UEMOA	Economic and Monetary Union of West Africa
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations International Development Organization
USAID	Untied States Agency for International Development
VRA	Volta River Authority
WACAF	West and Central Africa Action Plan for Abidjan Convention
WARAP-IWRM	Regional Action Plan for Integrated Water Resources Management
WHO	World Health Organization

Appendix C

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