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مشروع التقييم والمتابعة لقطاع المياه بدول شمال أفريقيا

Monitoring and Evaluation for Water In North Africa

CEDARE

N-AMCOW

African Water Facility
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Mobilising Resources for Water in Africa

Senegal River Basin
2012 State of the Water Report

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Donor: African Water Facility/African Development Bank
Grant Recipient: CEDARE
AWF Grant Agreement No.: 5600155002351
Project ID No.: P-Z1-EAZ-027
Document Name: Senegal River Basin 2012 State of the Water Report
Document Type: Regional
Version: English, Final Version
Countries: Guinea, Mali, Mauritania, Senegal
Region: Senegal River Basin
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Design & Layout: Eng. Tamer El-Hakim
Document Date: February, 2015

For reference purposes, this publication should be referred to as:
AbuZeid, K., Elrawady, M., CEDARE (2015). "Senegal River Basin 2012 State of the Water Report", Monitoring & Evaluation for Water In North Africa (MEWINA) Project, Water Resources Management Program, CEDARE.

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1. Introduction

The Senegal River basin (Figure (1)) is located in West Africa between latitudes10°30 and 17°30 N and longitudes 7°30 and 16°30 W, and covers 1.6% of the continent and spreads over four countries: Guinea, Mali, Mauritania, and Senegal. The Senegal River is the second largest river in West Africa. It is 1800 km long and drains into the Atlantic Ocean. The sources of the Senegal River are located in Guinea and in the wetter south-western part of Mali. The main tributaries, contributing 80% of the flow, are the Bafing, Bakoye, and Faleme Rivers which all originate in the Fouta Djallon Mountains located inGuinea. The Karakoro River and the Gorgol River with its two tributaries, the white Gorgoland the black Gorgol, both originate in Mauritania.

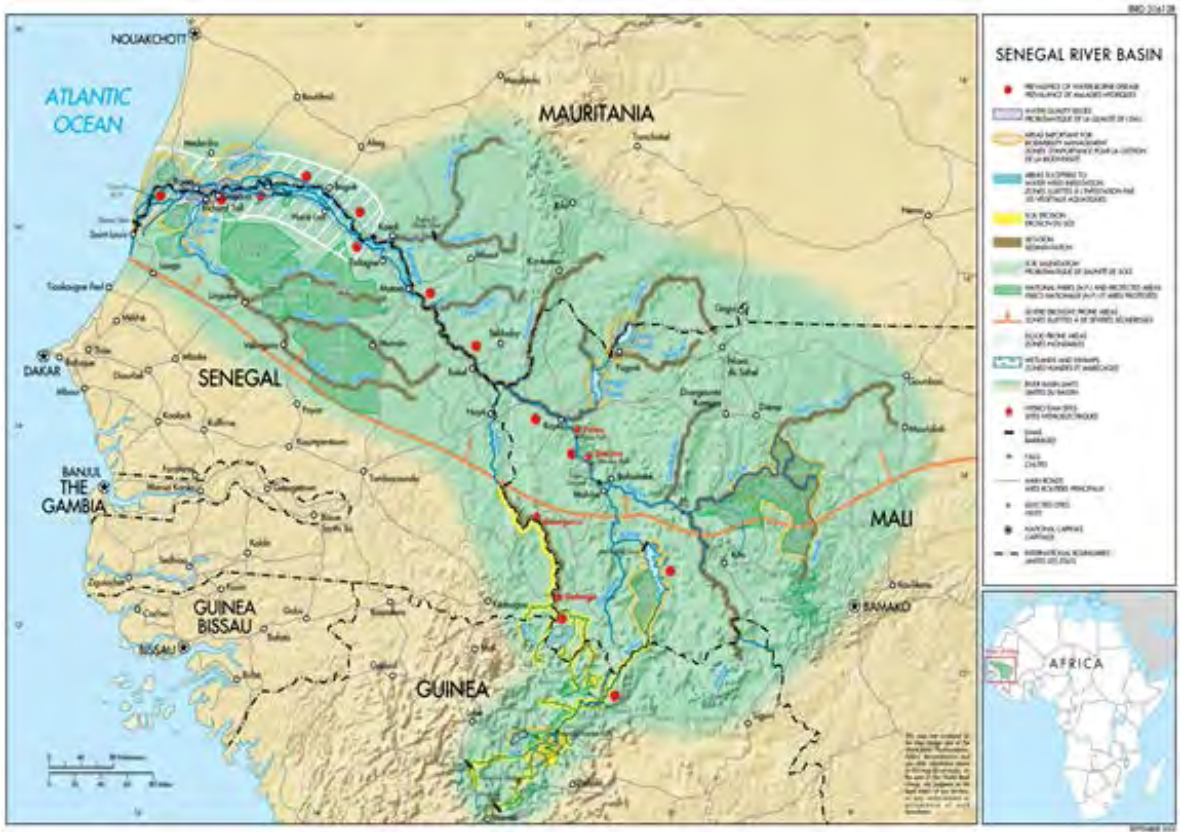


Figure 1. Senegal River basin

Total annual discharge leaving Guinea is estimated at about 8 km^3, but during the dry season the rivers frequently run dry. The Faleme River forms the border between Senegal and Mali and covers the most part of this border. By the time they reach the border point between Mali, Mauritania and Senegal, the different tributaries join to form the Senegal River, which then continues to form the border between Senegal and Mauritania. The Karakoro River flows into the Senegal River at roughly the same point. The annual discharge of the Senegal River at Bakel is 20 km^3. The Gorgol River joins it about 200 km downstream. Further downstream there are no other important tributaries. Lac de Guiers is a source of the freshwater supply for Dakar, the capital of Senegal. The construction of the Diama dam in 1986, located approximately 23 km from the river's mouth, has helped to raise the level of the upstream water body (confined by dykes along both shores) to facilitate irrigation, navigation and the filling of lac de Guiers in Senegal and lac Rqiz in Mauritania.

The Senegal River basin covers a surface area of about 300,000 km^2. The high plateau in northern Guinea covers 31,000 km^2 (11 percent of the basin), 155,000 km2are situated in western Mali (53 percent of the basin), 75,500 km^2 are in southern Mauritania (26 percent of the basin) and 27,500 km^2 are in northern Senegal (10 percent of the basin). The basin has three distinct parts: the upper basin, which is mountainous, the valley (itself divided into high, middle and lower) and the delta, which is a source of biological diversity and wetlands (Figure 2). Topographical, hydrographic and climatic conditions are very different in these three regions and seasonal temperature variations are extensive.

The Senegal River basin has a total population of around 3,500,000 inhabitants, 85 percent of whom live near the river. This figure includes approximately 16 percent of the total populations of Mali, Mauritania and Senegal, which are members of the Organization for the Development of the Senegal River Senegal River (OMVS), plus the population of the Guinean portion of the upper basin. The population within the basin is increasing at a rate of about 3 percent per year, which is slightly higher than the individual averages for the three member states. Main activities in the basin include irrigation, which is the main driver for development in the basin, livestock raising, fishing, mining, and some underdeveloped industries. As for hydropower generation, the hydroelectric power plant in Manantali has been in operation since September 2001 with a capacity of 200 MW, to furnish an average of 800 GWh/year to electricity companies in the three OMVS member states.

2. Shared River Basin State of the Water (SOW) indicators, Values, and Analysis

The Shared River Basin SOW indicators are divided into 12 categories as shown below:

2.1 Water & Availability

The main focus will be Blue Renewable Surface Water related to the Senegal Basin. The total precipitation on the whole basin and the associated green water consumption will be showcased whenever data is available. The indicators are as follows:

- **Annual Spatially Averaged Precipitation Depth:** Average precipitation over space in depth
- **Annual Precipitation Volume:** Average Precipitation over space in volume, it is the product of the Annual Average Precipitation Depth and the Effective Rainfall area.
- **Internal Renewable Blue Surface Water (IRSW):** The amount of precipitation that is neither beneficially abstracted from the atmosphere, nor infiltrated in the ground, but flows overland until the basin's outlet.

- **Internal Renewable Blue Groundwater (IRG):** Groundwater Recharge is the total volume of water entering underground sources of water (typically aquifers) within the basin's boundaries from endogenous (internal) precipitation and surface water flow
- **Total Internal Renewable Blue Water Resources (TIRBWR)=(IRSW+IRG):** Annual flow of

the river and recharge of aquifers generated from endogenous precipitation. Double counting of surface water and groundwater resources is avoided by deducting the overlap from the sum of the surface water and groundwater resources.

- **Surface Blue Water Inflows to Basin Countries:** Total blue surface water flowing into each basin countries within the Senegal Basin system
- **Surface Blue Water outflows from Basin Countries:** Total blue surface water flowing from each basin country within the Senegal Basin system
- **Overlap between Blue surface water and Blue Groundwater (OSW):** Part of the renewable freshwater resources that is common to both the river flow water and groundwater. It is equal to groundwater drainage into the river (typically, base flow of the river) minus seepage from the river into aquifers.
- **Green Water Consumption for Rain-fed agriculture:** The total amount of precipitation directly consumed by rain fed agriculture in the basin.
- **Green Water Consumption for Pasture Areas:** The total amount of precipitation directly consumed by pasture areas in the basin.
- **Green Water Consumption for Forest Areas:** The total amount of precipitation directly consumed by forests in the basin.
- **Total Renewable Green Water Resources:** The total amount of precipitation directly consumed by forests, pasture areas, and rainfed areas in the basin.
- **Total Renewable Water Resources (TRWR)=(TIRBWR+TRGWR):** The Total Renewable Water Resources is hence calculated as the sum of the total Internal Renewable Blue Water Resources and the total Green Water.

Table (1) shows the indicator values for the Water & Availability indicators.

Table 1.Water & Availability indicators values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Availability						
Annual Spatially Averaged Precipitation Depth	MM	550	1,475	855	270	520
Annual Spatially Averaged Precipitation Depth (Basin Countries)	BCM/Year	1,073	2,123	895	349	925
Annual Precipitation Volume	BCM/Year	265.74	43.47	118.9	37.3	37.33
Annual Precipitation Volume (Basin Countries)	BCM/Year	641.4	261	217	65.54	98
Internal Renewable Surface Water (IRSW)	BCM/Year	24.8				
Internal Renewable Groundwater (IRG)	BCM/Year				0.23	
Surface Blue Water Inflows to Basin Countries	BCM/Year					
Surface Blue Water Outflows to Basin Countries	BCM/Year					
Total Internal Renewable Blue Water Resources (TIRBWR)=(IRSW+IRG)	BCM/Year	24.8				
Overlap Between Surface Water and Groundwater (OSW)	BCM/Year	0	0	0	0	0

Green Water for Rain-Fed Agriculture	BCM/Year	5.29	2.15	2.83	0.09	0.22
Green Water for Pasture Areas	BCM/Year	8.57	4.6	0.01	3.94	0.02
Green Water for Forest Areas	BCM/Year	4.04	3.9	0.09	0.02	0.02
Total Renewable Green Water Resources	BCM/Year	17.89	10.65	2.94	4.05	0.26
Total Renewable Water Resources (TRWR)=(TIRBWR+TRGWR)	BCM/Year	43				

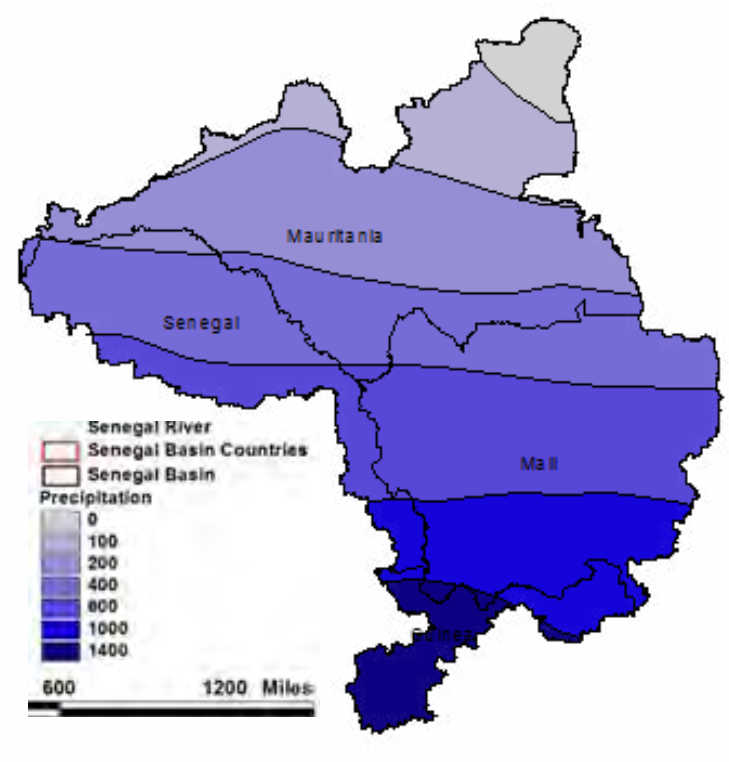


Figure 2a. Senegal River Basin Precipitation

Senegal River Outflows in to the Atlantic Ocean

Diama Barrage

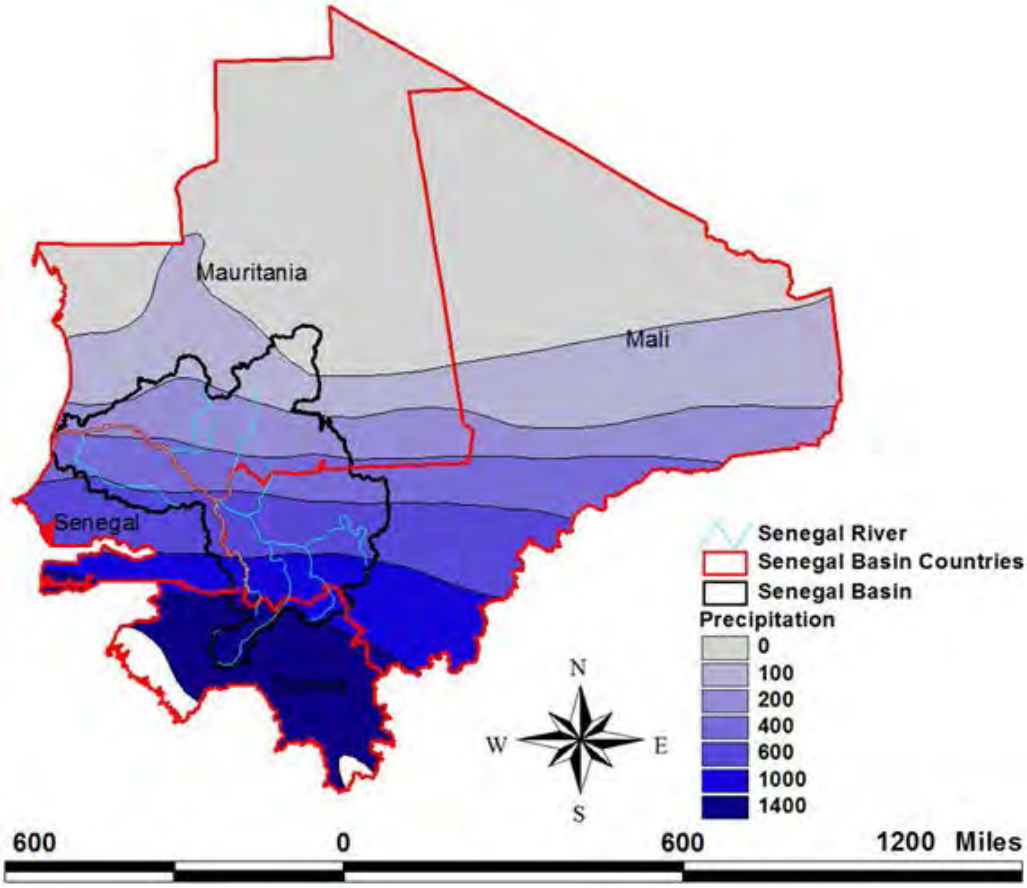


Figure 2b. Senegal River Basin and Senegal River Countries Precipitation

The heterogeneity of rainfall data in the Senegal River Basin is evident in Figure (2a); it ranges from 270 mm in the portion of the basin in Mauritania to 1475 mm in the portion of the basin in Guinea. The overall Annual Spatially Averaged Precipitation Depth for the Whole Basin has been assessed to be 550 mm; the annual spatially averaged precipitation depth for total countries precipitation as well as basin precipitations are shown are shown in figures (2b) and Figure (3). Based on the average Depths and the surface areas of the countries contributing to the basin shown in Table (2), the total annual spatially averaged volume of precipitation in the Basin and for the Whole Country has been assessed as shown in Figure (4). Despite having the highest Precipitation depth, Guinea has the second lowest in-basin precipitation volume after Mauritania, while Mali has the highest in-basin precipitation volume which amounts to around 119 BCM.

Table 2. Countries Surface Area within the Senegal Basin (FAO, 2012)

Country	Total area of the country (km^2)	Area of the country within the basin (km^2)	As % Of total area of basin (%)	As % of total area of country (%)
Guinea	245,857	2,9475	6.1	12.0
Mali	1,240,190	139,098	28.8	11.2
Mauritania	1,025,520	242,742	50.2	23.7
Senegal	196,720	71,866	14.9	36.5

Figure (5) shows the historical precipitation trends in three locations in Senegal (Matam, Bakel, and

Podor), one location in Mali (Nioro) and three locations in Southern Mauritania (Boghe, Selibaby, and Kiffa). Selibaby stands out as the rainiest location in Mauritania with precipitation trends close to those of Nioro. The overall historical trend shows a significant decrease in precipitation throughout the basin from the sixties to the seventies and eighties with a slight rebound starting from the early nineties.

The renewable Blue water resource in the basin is 25.025 BCM which is mainly surface water. Renewable Blue Groundwater resources are approximately 0.225 BCM.

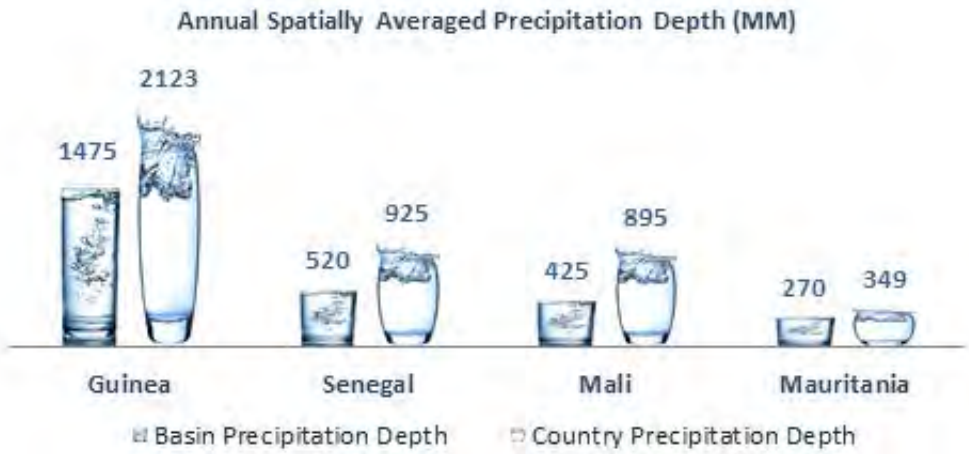


Figure 3. Annual Spatially Averaged Precipitation Depth

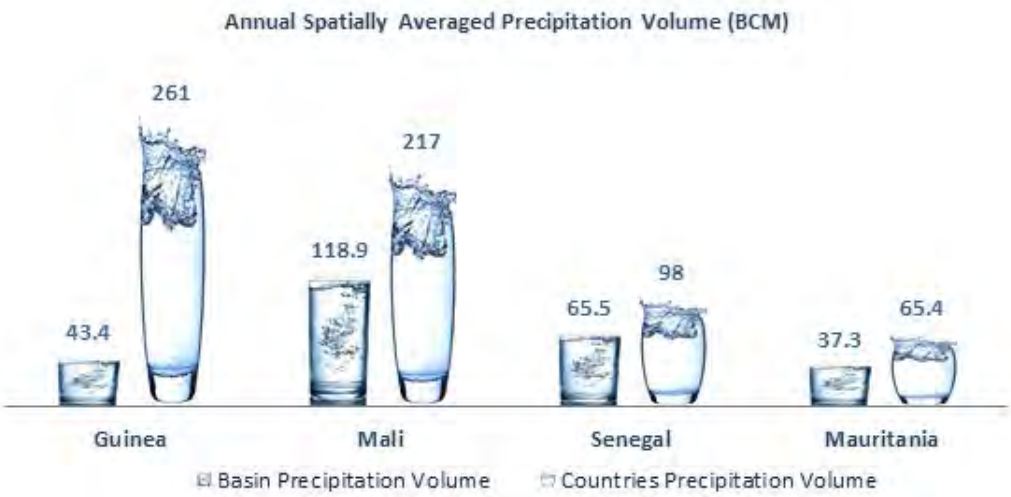


Figure 4. Annual Spatially Averaged Precipitation Volumes

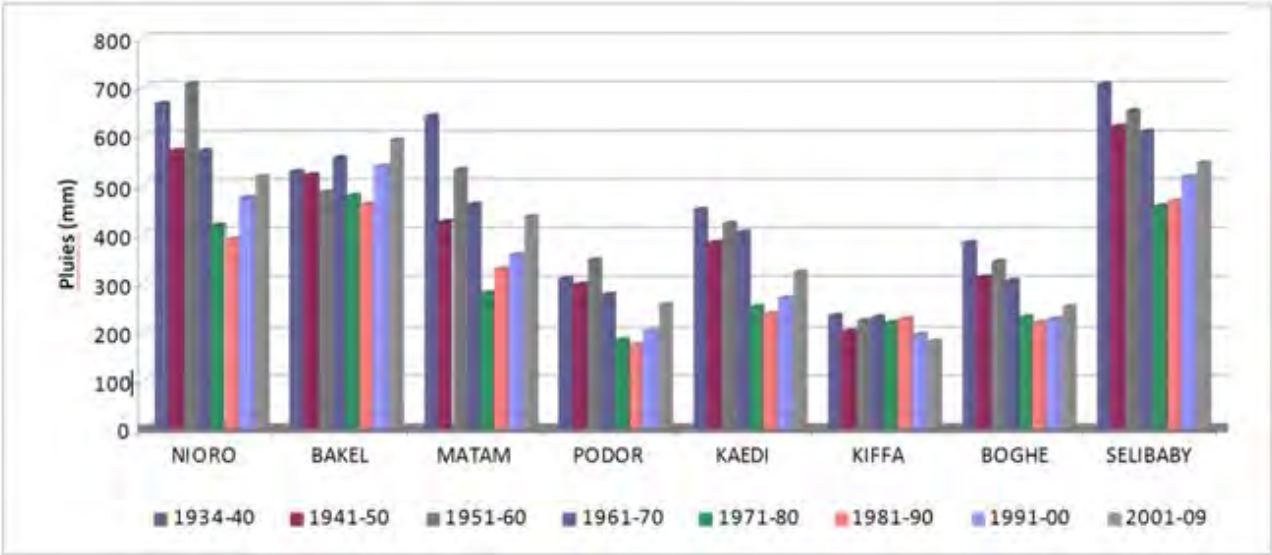


Figure 5. Historical Precipitation Trends in the Senegal Basin

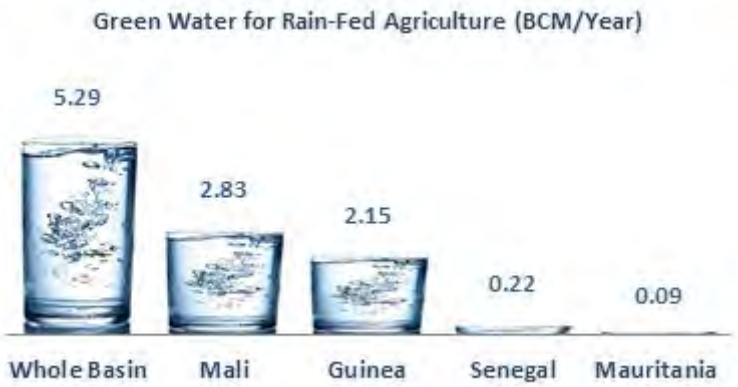


Figure 6. Green Water for Rainfed Agriculture

Figure 7. Total Renewable Green Water Resources

The Total Renewable Green Water Resources used in Rain-fed Agriculture amounts to 5.39 BCM as shown in Figure (6) with Mali Consuming most of that amount followed by Guinea. The Total Renewable

Green Water Resources for all the Basin countries except Guinea are shown in Figure (7), the relatively large amounts of Green Water in Mauritania and Senegal are attributed to the consumption of Natural pasture areas in both countries as shown in table (1).

2.2 Water & Uses

The main focus will be direct consumption from the transboundary river system of interest with some emphasis on direct beneficial consumption from green water within the basin. The indicators are as follows:

- **Withdrawals from Blue Surface water:** Annual gross amount of water extracted from river basin
- **Withdrawals from Blue Ground water: Annual gross amount of water extracted from Aquifers within the basin**
- **Withdrawals for the Domestic Sector: Total annual volume of blue surface water withdrawals used for domestic purposes in the basin.**
- **Withdrawals for the industrial sector: Total annual volume of blue surface water withdrawals used for industrial purposes in the basin.**
- **Withdrawals for the agricultural sector: Total annual volume of blue surface water withdrawals used for agricultural purposes in the basin**.
- **Greenwater Consumption for Agriculture:** The total volume of green water annually consumed by rain-fed agriculture.

Table (3)shows the indicator values for the Water & Uses indicators.

Table 3. Water & Uses Indicator Values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Uses						
Withdrawals from Blue Surface Water	BCM/Year	10.39	2.16	3.98	1.07	0.75
Withdrawals for the Domestic Sector	BCM/Year	0.19	0.01	0.03	0.07	0.09
Withdrawals for the Industrial Sector	BCM/Year	0.03	0.01	0.03	0.05	0.002
Withdrawals for the Agricultural Sector	BCM/Year	4.86	0	3.93	0.5	0.43
Greenwater Consumption for Agriculture	BCM/Year	5.29	2.15	2.83	0.09	0.22

The amount of green Water Consumption for Rain-fed agriculture is also reflected in the total agricultural withdrawals as it is the sum of both Blue and Green Water used for Agriculture. Figure (8) shows that the Agricultural Withdrawals dominate Water use in all basin countries.

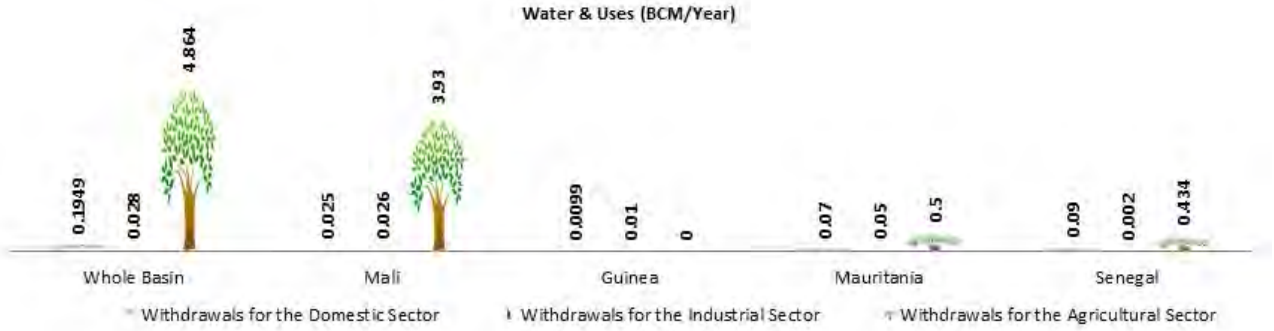


Figure 8. Water Uses in the Senegal Basin

Domestic withdrawals in the basin average 0.226 BCM with a value of 0.07 BCM in Mauritania, 0.09 BCM in Senegal, Mali 0.025 BCM, and 0.0099 BCM in Guinea. Water withdrawals for industry are relatively low in the Basin with an average of 0.013 BCM.

2.3 Water & Land Use Changes

This category will focus on the Land Use within the river's catchment area, the indicators are as follows:

- **Total Irrigated Agricultural land:** Total water managed agricultural area in the basin
- **Total Rainfed Agricultural land:** The total rainfed agricultural area
- **Total Pasture area**
- **Total Forests area**
- **Urban Encroachment on Agricultural land:** Is the loss of agricultural land caused by urbanization, and is expressed by agricultural area lost/ year
- **Impact of Urban Encroachment on agricultural land:** Is the amount of water resources gained or lost due to urban encroachment on agricultural lands and is assessed through the following indicators:

  a) The increase of surface runoff: under the assumption that most of the volume that used to infiltrate to the root zone will be changed into surface runoff due to the drastic difference in permeability between agricultural land and asphalt, the increase of surface runoff is estimated as 80-90% of the decrease in the amount of water infiltrated to the root zone in rainfed agriculture.

  b) The decrease in water consumption of Green Cover: defined as the product of the green cover

area lost due to urban encroachment and the average consumption of the unit area.

c) The increase in domestic water withdrawals: defined as the total volume used by the population that re-located to the abused areas which is given by the product of the estimated population and the annual average domestic water consumption per capita (100-200 cubic meters).

Table (4) shows the indicator values for the Water & Land Use Change indicators.

Table 4.Water & Land Use Change indicators values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Land Use						
Total Irrigated Agricultural Land	ha	87,856	229	227	17,400	70,000
Total Rainfed Agricultural Land	ha	86,041	297	683	44,586	40,875
Total Pasture Area	ha	43,669,500	11,626,800	27,642,000	18,100	4,382,700
Total Forests Area	ha	14,812,100	9,789,700	1,253,700	0	37,687
Urban Encroachment on Agricultural Land	Area Lost/Year					
Impact of Urban Encroachment on Agricultural Land (Indicators listed below)						
The Increase of Surface Runoff	BCM/Year					
The Decrease of Agricultural Withdrawals in Case of Irrigated Agriculture	BCM/Year					
The Increase in Domestic Water Withdrawals	BCM/Year					

In terms of land use, Figure (9) shows the irrigated and rainfed agriculture in the basin. It is clear that the total area of rainfed agriculture is almost equal to the irrigated agriculture, with Mauritania showing the highest dependence on rainfed agriculture followed by Senegal. The latter has the most developed irrigated land in the whole basin. Figure (10) shows the land cover distribution in the basin.

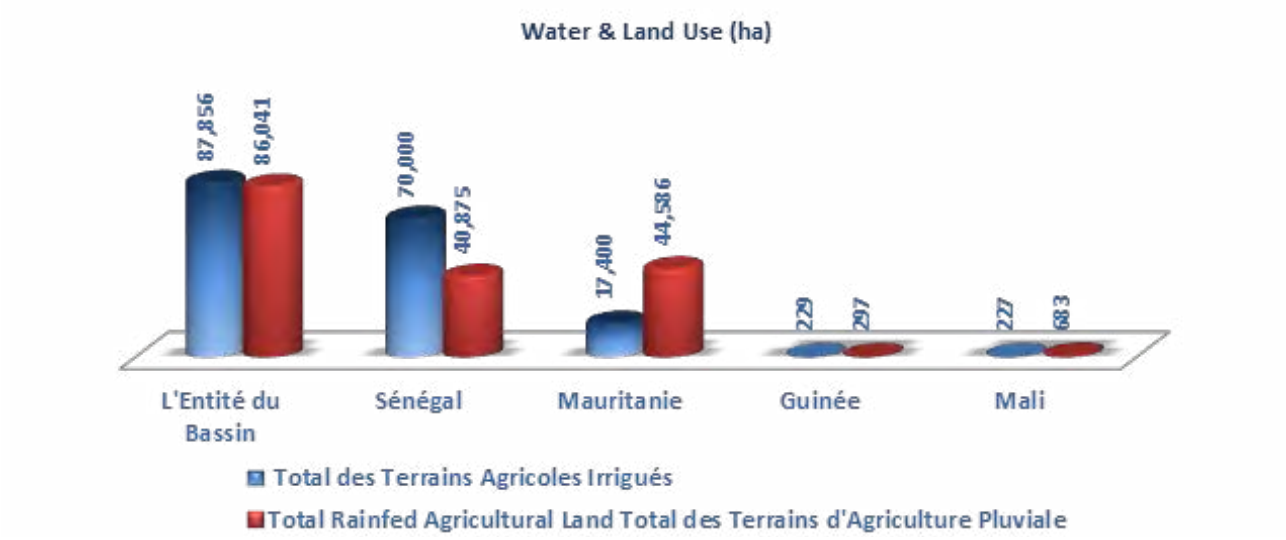


Figure 9. Agricultural Areas in the Senegal Basin

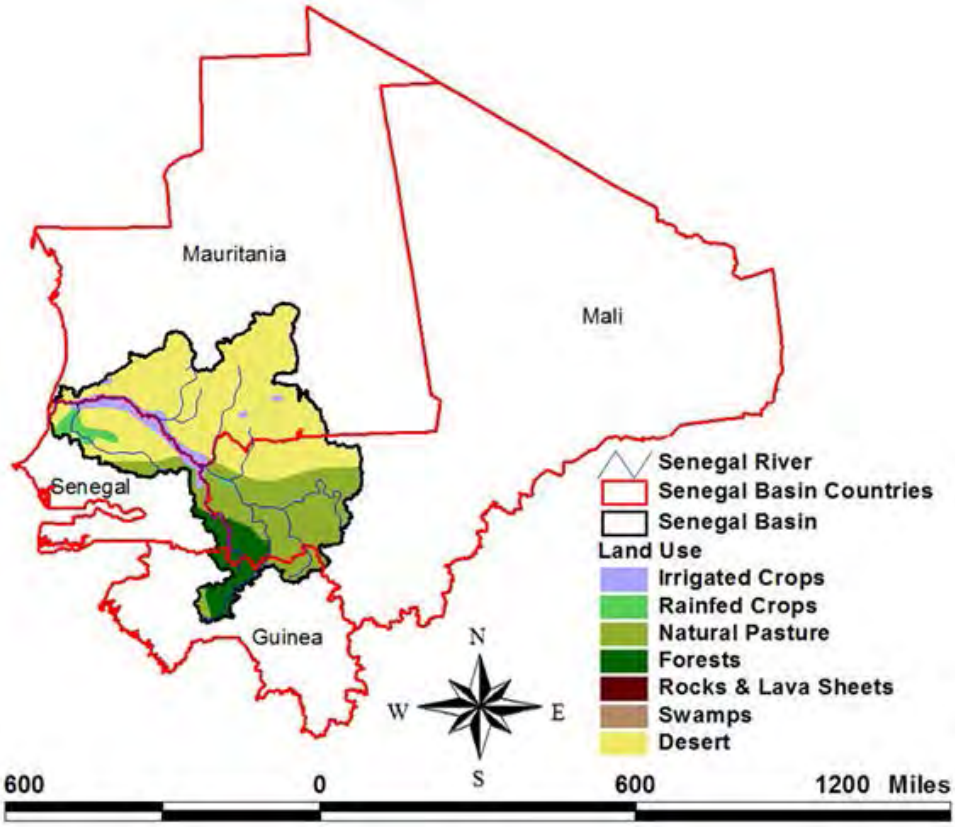


Figure 10. Land use map in the Senegal Basin (OMVS)

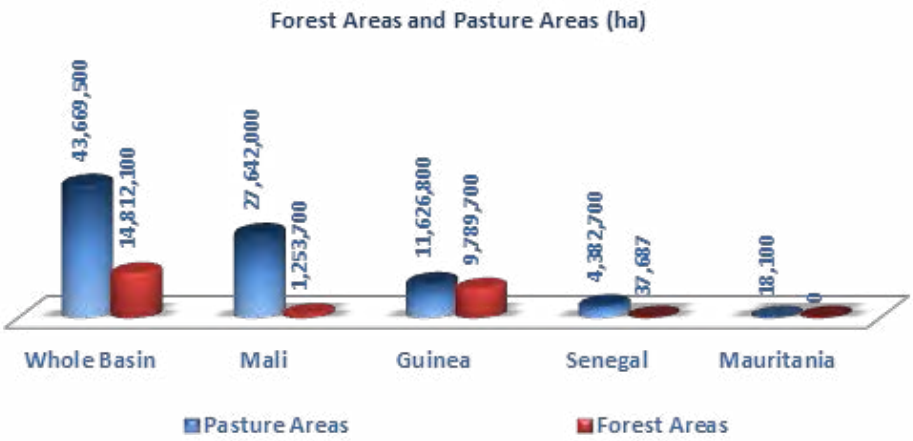


Figure 11. Forest Areas and Pasture Areas in the Senegal Basin (ha)

Figure (11) shows the forest areas and natural pasture areas in the basin, it is clear that Mauritania ,being a desert country ,has the least areas for both land uses

2.4 Water & Energy

This category will focus on the infrastructure related to power generation on the river of interest, the indicators are as follows:

- **Electricity Generated using Hydropower:** Hydropower production as percent of total electricity production (World Bank). And, the Hydropower generated per year.
- **Electricity Generated using Hydropower as a percent of all generated Electricity**
- **Installed Hydrocapacity:** Sum of all generator nameplate power ratings (in GW) from the installed Hydropower Plants (AMCOW, 2012).
- **Water used to generate electricity:** The total annual volume of inflow through all hydro generators.

Table (5) shows the indicator values for the Water & Energy indicators.

Table 5. Water & Energy indicators Values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Energy						
Electricity Generated Using Hydropower	GWh/Year	999				
Electricity Generated Using Hydropower as a percent of all Electricity generated	%					
Volume of Water Used to generate Hydropower	BCM/Year					
Installed Hydrocapacity	MW	200		104	30	66

Table (5) shows that the installed Hydrocapacity in the Senegal Basin in the three basin countries that were members of the Organization for the Development of the Senegal River (All except Guinea who joined later) according to a benefits sharing agreement in 2002, while the total electricity generated was estimated at all basin countries was 999 GWH/ Year.

2.5 Water & Services

This category will focus on the infrastructure related to storage on the river of interest, the indicators of this category are as follows:

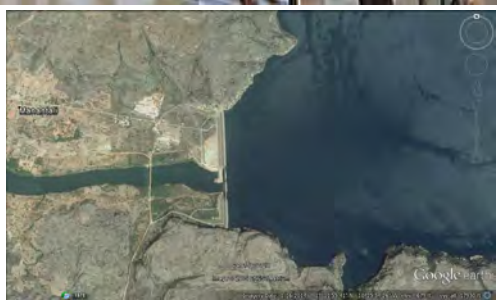
- **Dam Storage capacity:** The total capacity of all water regulating structures installed in the basin.
- **Maximum Annual Dam Storage Reached:** is the actual storage reached in a given year, which should always be lower than the Dam Storage Capacity.
- **Water Supply Coverage**
- **Sanitation Coverage**

Table (6) shows the indicator values for the Water & Services indicators.

Table 6. Water & Services indicators values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Services						
Dam Storage Capacity	BCM/Year	11.5		11.5		
Maximum Annual Dam Storage Reached	BCM/Year					
Water Supply Coverage	%	67	59	63	55	91
Sanitation Coverage	%	38	32	21	50	50

The annual dam storage capacity in the Senegal Basin was estimated to be 11.5 BCM which is mainly related to the Mantali dam. The Water supply coverage average is 67% in the basin countries with Senegal having the highest coverage of 91%, while the Senegal Basin countries average is 38% with Mauritania and Senegal having the highest coverage of 50%.



2.6 Water & Population

This category features different demographical data about the Senegal basin based on the total population of the basin which is different than the total population of the basin countries, the indicators are:

- **Total Population of the Basin**
- **Internal Renewable Water Resources per Capita:** annual flow of the river and recharge of aquifers generated from endogenous precipitation, on a per person basis (Modified from FAO).
- **Total Renewable Water Resources per Capita:** Is the sum of total internal renewable blue and green water resources, on a per person basis.
- **Green Water Consumption Per Capita:** The total amount of precipitation directly consumed by pasture areas, rainfed areas, and forest areas in the basin, on a per person basis.
- **Total Water Consumption Per Capita:** The gross amount of water extracted from the basin's surface water, on a per person basis.

- **Agricultural Water Withdrawal Per Capita:** The sum of total agricultural abstractions from the basin's surface water, and direct beneficial abstractions from precipitation in rain-fed areas in the basin, on a per person basis.
- **Industrial Water Withdrawal Per Capita:** Total annual volume of water withdrawals from the basin's surface water used for industrial purposes on a per person basis.
- **Domestic Water Withdrawal Per Capita:** Total annual volume of water withdrawals from the basin's surface water used for domestic purposes on a per person basis.

Table (7) shows the indicator values for the Water & Population indicators.

Table 7. Water & Population Indicators Values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Population						
Total Population in the Basin	Number	5,633,414	1,033,390	2,769,279	800,257	1,030,488
Internal Renewable Water Resources Per Capita	CM/Capita	4,402				
Total Renewable Water Resources per Capita	CM/Capita	7,633				
Green Water Consumption Per Capita	CM/Capita	957	2,081	1,022	225	217
Total Water Consumption Per Capita	CM/Capita	1,326	2,371	1,438	712	510
Agricultural Water Withdrawal Per Capita	CM/Capita	1,276	2,361	1,419	625	421
Industrial Water Withdrawal Per Capita	CM/Capita	20.8	10	9.3	62	1.9
Domestic Water Withdrawal Per Capita	CM/Capita	47	10	9	87	87

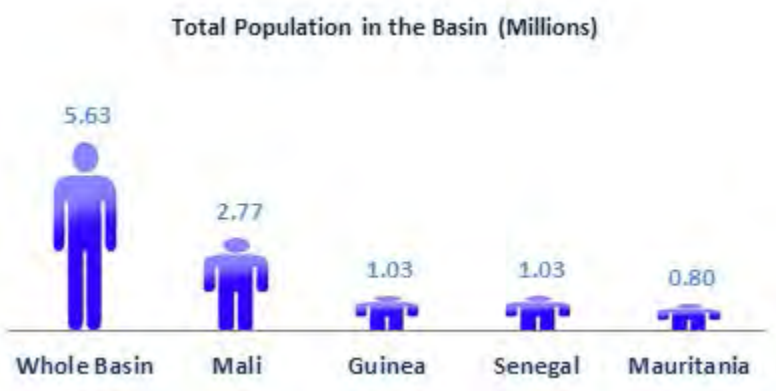


Figure 12a. Populations in the Senegal Basin

As far as the population inside the basin is concerned, the majority are situated in Mali, with 2.77 out of 5.63 Million Inhabitants and the remaining three countries having approximately close populations as shown in Figure (12a). Guniea has the highest per capita Green Water and Total Water Consumptions which by far exceed the whole basin average as shown in Figure (12b).

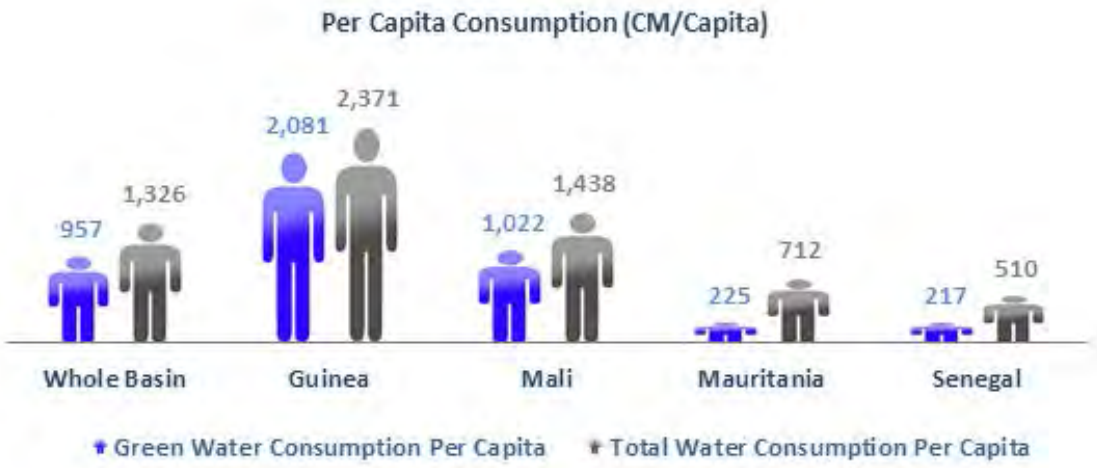


Figure 12b. Per Capita Water consumption in the Senegal Basin Countries

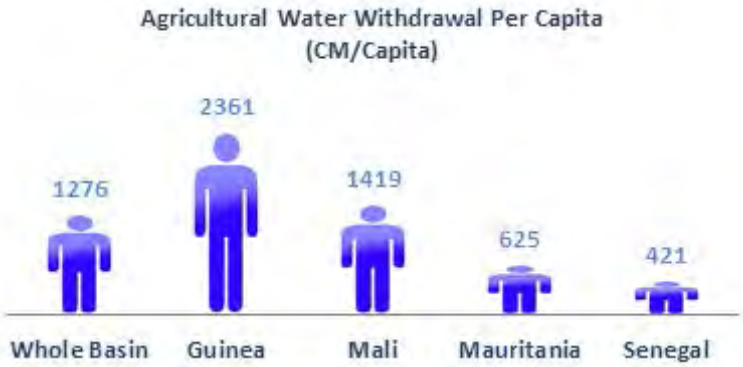


Figure 13. Agricultural Water withdrawals Per Capita

Figures (13) through (15) show the Per capita shares of Agricultural, Industrial, and Domestic Withdrawals, respectively. While Guinea has the highest per capita share of Agricultural Withdrawals, Mali has the highest per capita share of Industrial withdrawals, although the values are significantly low for all countries. The highest per capita share for Domestic water Withdrawal is a tie between Senegal and Mauritania as shown in Figure (15).

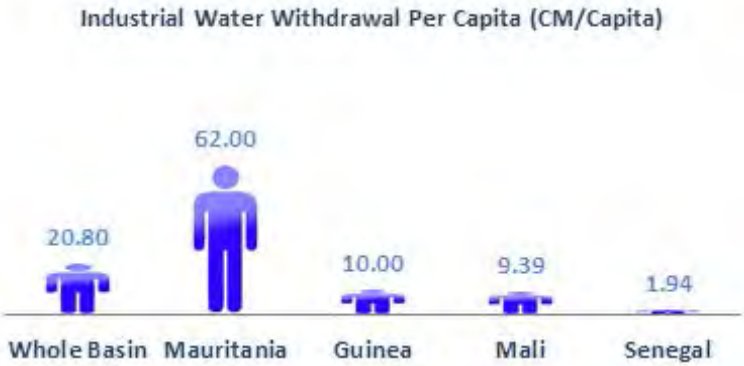


Figure 14. Industrial Water withdrawals Per Capita

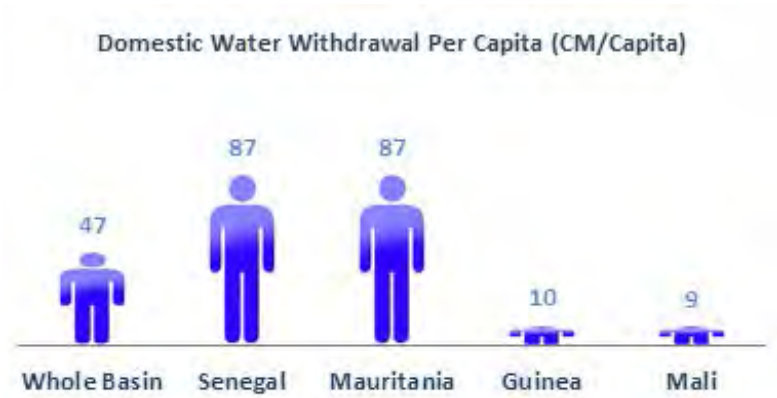


Figure 15. Domestic Water withdrawals Per Capita

2.7 Water & Quality

The following indicators should be measured or reported for in all surface water quality monitoring stations in each country within the basin area to identify the average, minimum, and maximum values for each indicator, the values of all of these indicators are directly connected to anthropogenic activities:

- **Dissolved oxygen (ppm):** is a measure of free (i.e., not chemically combined) oxygen dissolved in water. It is essential to the metabolism of all aerobic aquatic organisms. Reduced levels could harm and even kill plants and fish.
- **pH (dimensionless):** is a measure of the acidity or alkalinity of a water body. It can affect aquatic organisms both directly, by impairing respiration, growth, and development of fish, and indirectly, by increasing the bioavailability of certain metals such as aluminum and nickel.
- **Electric Conductivity:** measured in 1/OHM (S/M) is a measure of the ability of water to carry an electric current, which depends on the presence of ions. Increases in conductivity can lead to changes that reduce biodiversity and alter community composition.
- **Total Dissolved Solids (ppm):** is a measure of the combined content of all organic and inorganic substances contained in a water sample.
- **Nitrogen Concentration (ppm):** Nitrogen and phosphorus are naturally occurring elements essential for all living organisms. But they are often found in growth-limiting concentrations in aquatic environments. Increases in nitrogen or phosphorus in natural waters, largely as a result of human activities in the drainage basin (e.g., from agricultural runoff from manure and synthetic fertilizers, and from municipal and industrial waste-water discharge), can overstimulate plant growth and choke off oxygen supplies.
- **Phosphorous Concentration (ppm):** See above.

Table (8) shows the indicator values for the Water & Quality indicators.

Table 8. Water & Quality indicators

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Quality						
Dissolved Oxygen (DO)	ppm				6.5	
pH	Dimensionless				7.8	
Total Suspended solids	ppm					
Total Dissolved Solids	ppm					
Nitrogen s Concentration	ppm					
Phosphorous Concentration	ppm					

The Average dissolved Oxygen Value in the Mauritanian portion of the Basin was estimated to be 6.5 ppm, while the average PH value is 7.8 as shown in table (8).

2.8 Water & Ecosystems

The indicators under this category are as follows:

- **Number of wetlands sites:** Including those acknowledged by RAMSAR, Sabkhas, Groundwater-based wetlands, and water bodies of special importance in the Basin.
- **Total Wetlands areas (to be calculated by earth observation tools)**.
- **Number of Endangered species:** The total number of endangered species that dwells partially or permanently in the water bodies inbounded within the Basin.
- **Number of Invasive species:** The total number of invasive species that dwells partially or permanently in the water bodies inbounded within the Basin.
- **Total Freshwater Species Count:** The total number of species that dwells partially or permanently in the water bodies inbounded within the Basin.

Table (9) shows the indicator values for the Water & Ecosystems indicators.

Table 9. Water & Ecosystems indicators values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Ecosystems						
Number of Wetlands Sites Acknowledged by RAMSAR (Inside the Basin)	Number	18	8	1	4	5
Total Wetlands Areas in the Basin	Number	75,96,304	2,136,211	4,119,500	1,240,600	99,993
Number of Endangered Species	Number					
Number of Invasive Species	Number					

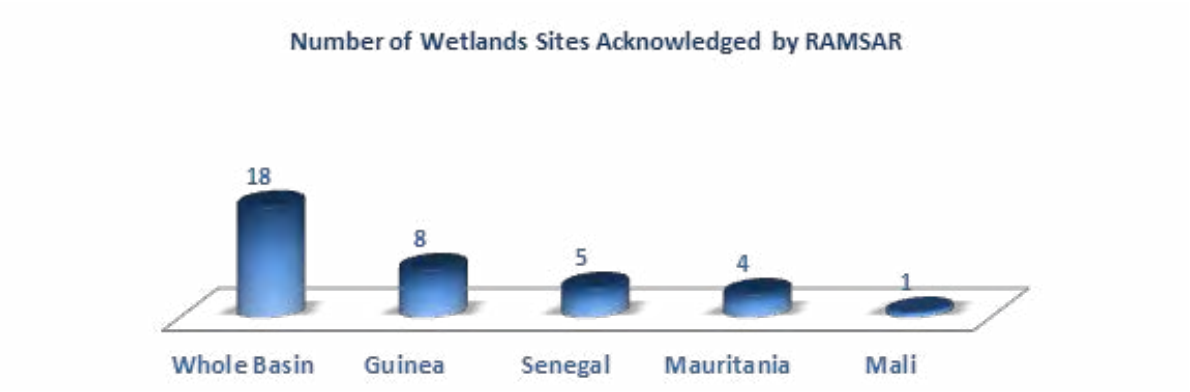


Figure 16. RAMSAR Wetland Sites in the Senegal Basin

Looking at the ecological and environmental aspects of the Basin, wetlands are major features of the Basin as indicated by figure (16) that shows that there are a total number of 18 RAMSAR acknowledged sites in the basin, 8 of them in Guinea, 5 in Senegal, 4 in Mauritania, and 1 in Mali. However, despite having only one RAMSAR acknowledged wetland site, Mali has the largest area of wetlands in the whole basin followed by Guinea as shown in Figure (17).

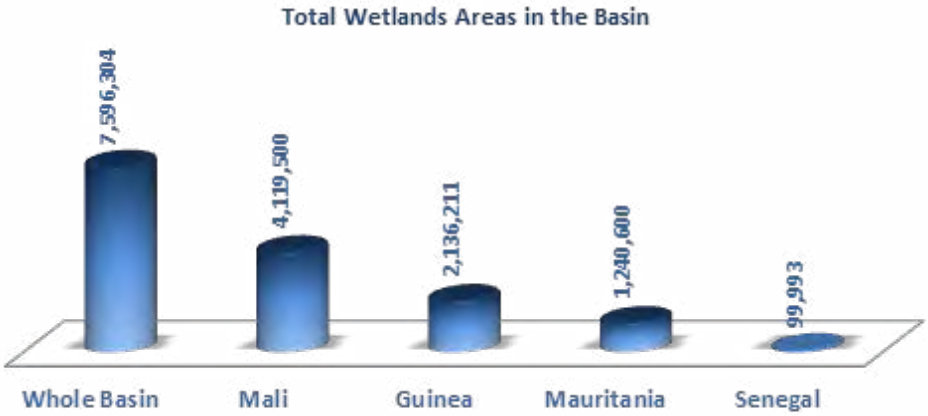


Figure 17. Wetlands Areas in the Senegal Basin

2.9 Water & Climate

Extreme Weather Events within the Basin's Domain

- **Number of Class 1 flood events:** Class 1 floods are large flood events causing significant damage to structures or agriculture; fatalities; and/or 1-2 decades-long reported interval since the last similar event (Dartmouth, 2013)
- **Number of Class 1.5 flood events:** Class 1.5 floods are very large events: with a greater than 2 decades but less than 100 year estimated recurrence interval, and/or a local recurrence interval of at 1-2 decades and affecting a large geographic region (> 5000 sq. km) (Dartmouth, 2013)
- **Number of class 2 flood events:** Class 2 flood events are extreme events with an estimated recurrence interval greater than 100 years (Dartmouth, 2013)
- **Drought events:** a drought event is a long period of abnormally low rainfall, especially one that adversely affects growing or living conditions. The abnormally low rainfall will be taken as 25% of the record monthly average. In other words, a period where rainfall has been consistently lower than 25% of the record average will be considered a drought event.

- **Cost of Annual damage induced by floods:** estimate to be reported by the national authority
- **Cost of Annual damage induced by droughts:** estimate to be reported by the national authority
- **Annual human losses related to Floods.**
- **Annual human losses related to Droughts.**

The Water & climate indicators have not been assessed for the Senegal Basin for the year 2012.

2.10 Water & Socio-Economics

The following indicators relate directly the the socio-economic aspects of the Senegal Basin:

- **Industrial water productivity:** It is the ratio of the Industrial GDP to the industrial withdrawals
- **Agricultural water productivity (Crop per Drop):** It is the ratio of the Industrial GDP to the industrial withdrawals.
- **Employment in Agriculture "Job per Drop":** The ratio of total labor employed in Agriculture in the Basin to the total agricultural withdrawals from the Basin (including irrigation withdrawals and rain fed agriculture green water consumption)
- **Employment in Industry "Industry Job per Drop":** The ratio of total labor employed in Industry in the Basin to the total industrial withdrawals from the Basin.

Table (10) shows the indicator values for the Water & Ecosystems indicators.

Table 10. Water & Socio-Economics indicators values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Socio-Economics						
Industrial Water Productivity	$/CM			177.36		3,146.2
Agricultural Water Productivity "Crop Per Drop"	$/CM	3.80	1.18	1.85	2.772	9.52
Employment in Agriculture "Job Per Drop"	Jobs/MCM	0.003	0.002	0.0007	0.001	0.01
Employment in Industry"Job Per Drop"	Jobs/MCM			0.03		0.69

Figure 18. Industrial Water Productivity

Figure 19. Agricultural Water Productivity

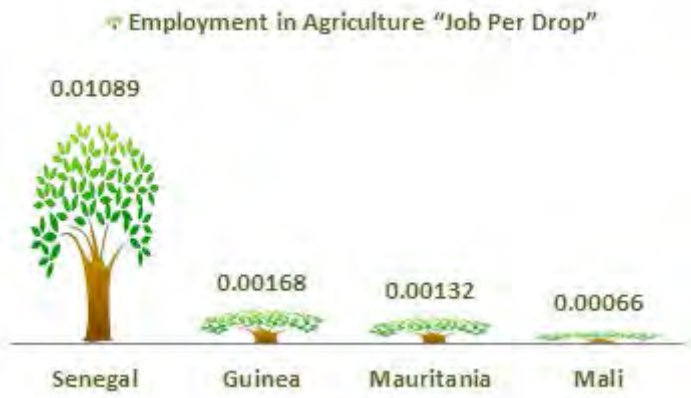


Figure 20. Employment in Agriculture

Figure 21. Employment in Industry

Figures (18) through (21) summarize the socio-economic impact of water withdrawals within the Basin. As it is commonly known, the Industrial Water productivity is drastically higher than the Agricultural Water Productivity with Senegal having the highest value for both indicators. However, while it was expected that Agriculture creates more job opportunities, it has been proven that the relatively small volumes of water used for industry could also offer more jobs compared to those offered by the huge volumes withdrawn by Agriculture as shown in Figures (20) and (21).



2.11 Water & Trade

The following indicators are related to the trade of virtual water in the Senegal Basin countries:

- **Total Agricultural Virtual Water Import:** Total inflow of virtual water which in turn is defined as the volume of freshwater used to produce the product, measured at the place where the product was actually produced (Hoekstra and Chapagain, 2001).
- **Total Agricultural Virtual Water Export:** Total outflow of virtual water which in turn is defined as: the volume of freshwater used to produce the product, measured at the place where the product was actually produced (Hoekstra and Chapagain, 2001).

Table (11) shows the virtual Water imports and exports for Mauritania as 2.64 BCM, and 0.03 BCM respectively.

Table 11. Water & Trade Indicator values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & Trade						
Total Inflow of Virtual Water	BCM/Year				2.64	
Total Outflow of Virtual Water	BCM				0.03	

2.12 Water & International Relations

- **Dependency Ratio:** the percent of annual volumes abstracted from the Basin of interest to total annual available water resources.
- **Shared Waters related Bilateral / Multilateral Agreements and/or Memorandums of Understanding and Cooperation Mechanisms:** The number of Bilateral or Multilateral agreements or other sort of cooperation a particular country is involved in. These agreements should be solely intended for transboundary water resources.
- **Presence of Other Shared Water Bodies in Riparian Countries**

Table (12) shows some of the indicators values for Water & International Relations for Mauritania, where it is clear that Mauritania is almost entirely dependent on the Senegal Basin. It is also shown that Mauritania has 4 agreements and/or memorandums of understandings with Senegal River Basin Riparians concerning beneficial cooperation.

Table 12. Water & International Relations Indicator values

	Units	Whole Basin	Guinea	Mali	Mauritania	Senegal
Water & International Relations						
Dependency Ratio	%	NA			96	
Number of Bilateral/ Multilateral Agreements & Memorandums of Understanding and Cooperation Mechanisms	Number	NA			4	
Presence of Other Transboudray Bodies in Riparian Countries	Number	NA				

With the drought that has developed since 1972/1973, the leaders of three riparian States of the Senegal River (All except Guinea) decided in 1972 to join efforts within the Organization for the Development of the Senegal River (OMVS). In addition to the agreements on OMVS establishment and on the legal status of the Senegal River, a Convention on the legal status of common infrastructures was signed on 21 December 1978 by the Heads of State and Government of Mali, Mauritania and Senegal, who decided in 1974 that installations of common interest on the Senegal River would jointly belong to the Member States of the OMVS. The Convention on the financing arrangements for common infrastructures was signed on 12 May 1982 in Bamako. Due to potential conflicts between power generation and the other uses of the Senegal River, the governments have embarked through OMVS on the implementation of an environmental impact alleviation and follow-up program.

Cooperation in the Senegal Basin started in the early 1980s; the OMVS received loans and grants from various funding agencies to finance this major infrastructure program. The contribution it would make to irrigation, energy production and navigation was calculated as well as the overall benefits to each member country (GWP and INBO, 2009) as follows:

Benefit	Mali	Mauritania	Senegal
Irrigation	11%	31%	58%
Energy production	52%	15%	33%
Navigation	82%	12%	6%
Overall	35%	23%	42%

OMVS can be considered as an example and a catalyst for Peace and Regional Stability where the concept of benefit sharing was successfully applied to hydropower. The jointly owned 1500 km power transmission lines connecting the three riparian countries power grids from Manantali dam were the subject of joint cooperation. The power is shared based on critical needs: Mali (104 MW or 52%), Mauritania (30 MW or 15%, and Senegal (66 MW or 33%).

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