Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details, please refer to the chapter describing the GIWA methodology.

Stream flow modification – Senegal River Basin

The Senegal River Basin is located in West Africa and occupies an area of roughly 475 000 km^2 (Figure 3 in the Regional definition). The entire Basin, including the upstream catchments, is drained by the 1 800 km-long Senegal River and its tributaries. The area of the River Basin accounts for about 1.6% of the African continent and lies within the territory of four different countries: Guinea, Mali, Mauritania and Senegal (Table 20).

The Basin is divided into three distinct regions; the upper basin lies in the mountains of Mali; the middle valley forms the 500 km long border between Senegal and Mauritania; and the delta in the lower valley is where the Senegal River discharges into the Atlantic Ocean. The delta is about 80 km long and consists of numerous estuaries that form a complex canal system.

The management and the development of water resources in the Basin are carried out within the framework of the Organisation for the Development of the Senegal River Basin (OMVS), which represents Mali, Mauritania and Senegal. During the last 30 years, important

Table 20 Countries in the Senegal River Basin.

Country	Country area (km^2)	Country area within the Basin		% of the total area of the country
		(km^2)	%	
Guinea	245 857	30 610	6.4	12.5
Mali	1 240 190	48 940	31.2	12.0
Mauritania	1 025 520	219 710	45.9	21.4
Senegal	196 720	78 680	16.5	40.0
Senegal River Basin		477 940	100	

(Source: Finger & Teodoru 2003, EROS Data Center 2003, ESRI 2002)

actions have been conducted, particularly the implementation of the hydroagricultural and the hydroelectric infrastructures as well as the extension of urban areas. The consequences of these actions have been a reduction of freshwater resources linked to the modifications of the observed regime of the River as well as deterioration of water quality and the lowering of the groundwater table.

Table 21 Rainfall in the Senegal River Basin.

Country	Average annual rainfall in the Basin (mm)		
	Min	Max	Mean
Guinea	1 120	2 100	1 475
Mali	455	1 410	855
Mauritania	55	600	270
Senegal	270	1 340	520

(Source: Finger & Teodoru 2003)

System description

The Senegal River is the second largest river in West Africa. It is formed by the confluence of two smaller rivers, the Bafing and the Bakoye, which occurs near Bafoulabé in Mali, about 1 083 km from the Atlantic Ocean. Downstream of Bafoulabé the River flows northwest, crossing the arid lands of western Mali. About 200 km further downstream, the Falémé River gushes into the Senegal River. From this point on the Senegal River forms a natural border between Mauritania and Senegal flowing westwards towards the Atlantic Ocean. All three main tributaries of the Senegal River (the Bafing, Bakoye and Falémé) have their sources in the Fouta Djallon Mountains of Guinea and in the southwestern part of Mali. Several other small tributaries, originating in Mauritania, also discharge into the Senegal River. One of them, the Karakoro River, enters the Senegal River at more or less the same point as the Falémé River. About 200 km further downstream, the Gorgol River enters the Senegal River. Downstream from Bakel, the River does not have any more important tributaries. The slope of the streambed decreases gradually until the River is essentially flat in the valley and the delta. This area is characterised by a broad flood plain and many depressions supplied by the river flow: Lake Guiers, Lake R'kiz, Three Backwaters and Djoudj. The Senegal River discharges in the Atlantic Ocean downstream from St Louis City.

The Senegal River Basin presents many geological, topographic, climatic and hydrological contrasts due to its extension between latitudes 11° N and 18° N. The eastern and the southeastern parts of the Basin consist of geologic formation from the Precambrian era (Fouta Djallon Mountains), characterised by impermeable rocks such as schists and granites, and clay soils. The topography is undulating and the elevation can exceed 1 000 m. To the west, elevations are relatively low and can be below sea level.

The climatic regime in the Basin can be divided into three seasons: a rainy season from June to September, a cold and dry season from October to February, and a hot and dry season from March to June. Rainfall in the Basin can be as high as about 2 000 mm per year. In the valley and the delta, it is generally low and exceeds rarely more than 500 mm per year (Table 21) (Finger & Teodoru 2003). Flooding can occur during the high flow period between June and October. During this high water period, the River overflows its banks and floods the broad alluvial plain of the middle valley. This has enabled farmers to grow crops during the dry season, after the waters have receded and the low-water period has started. In areas of low rainfall, the River's annual flood is a necessity to life.

The flow rate of the River depends mainly upon events in the upper basin in Guinea, which is, hydrologically speaking, the most active part of the Basin. The total annual discharge leaving Guinea is estimated at about 8 km^3, with an increase as a result of the inflow of the different tributaries of up to 20 km^3 by the time the River reaches the meeting point at the juncture of Mali, Mauritania and Senegal (SGPRE 1994). The mean annual discharge and volume of the main tributaries are shown in Table 22.

Table 22 Hydrological characteristics of the main tributaries of the Senegal River.

River	Outlet/control station	Mean annual discharge (m^3/s)	Mean volume (km^3)
Bafing	Bafing Makana	271.0	8.55
Bakoye	Toukoto	58.4	1.84
Baoulé	Siramakana	44.9	1.42
Falémé	Kidira	148.0	4.67
Senegal Basin	Bakel	648.0	20.40

(Source: SGPRE 1994)

The Senegal river flow is controlled by two dams, the Diama and the Manantali. The Diama Dam is located 30 km upstream of the city of St Louis. It was built in 1986 in order to stop the dry season intrusion of seawater along the river bed. In fact during dry years, saltwater could penetrate as far as 100 km inland, which makes the whole delta unsuitable for agriculture use (Gac 1986a & 1986b). The construction of the Diama was supplemented by the damming of the upper left and right bank located between Rosso and Diama. The second dam,

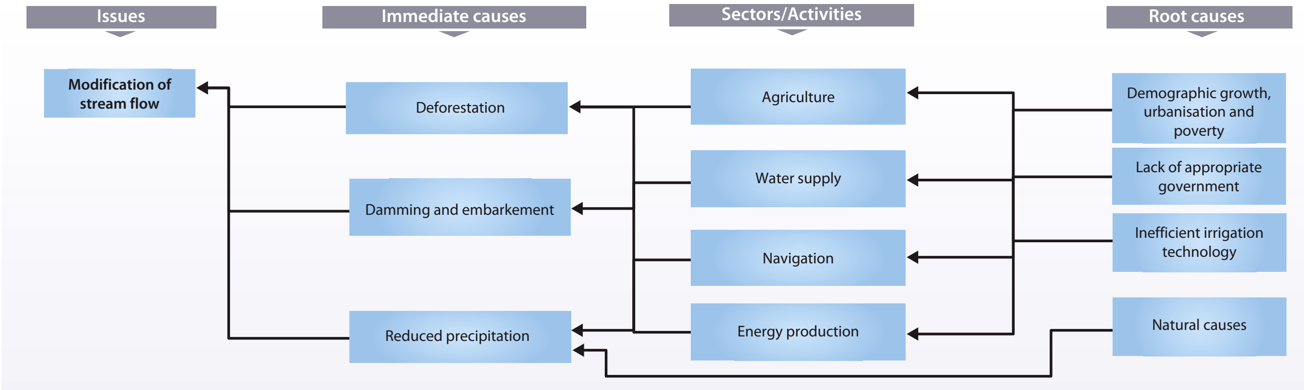

Figure 12 Causal chain diagram illustrating the causal links for stream flow modification in the Senegal River Basin.

the Manantali, was completed in 1988 and is located in Mali 1 200 km upstream from the Senegal River outlet. Its storage capacity is 12.8 km^3. It was built on the Bafing River, which supplies approximately 60% of the annual flow of the Senegal River in a reservoir (Gac 1986a,b).

The major development objectives assigned to the two dams are (SGPRE 1994, OMVS/SOGED 2003):

- Regulate the River's discharge at a rate of 2 500 m^3/s during the rainy season to allow the traditional flood-recession farming;
- Regularisation of river flows to 300 m^3/s at Bakel;
- Irrigate 375 000 ha of former floodplain for two crops per year, especially for rice production;
- Produce hydropower (800 GWh per year);
- Provide a 1 500 km transport line network to assure energy delivery to inter-connected networks in the three member states;
- Make the River navigable all year round between Saint Louis at the river mouth and Ambibédi in Mali (about 900 km).

In 1988, the population of the Basin was 1.55 million inhabitants, including 767 000 Senegalese, 696 000 Mauritanians and 80 000 Malians (OMVS/SOGED 2003). With a growth rate of 2.2%, the population in 2000 was a little bit over 2 million inhabitants. The population is concentrated mainly in rural areas; however recent demographic trends show a tendency for an increase in the urban population. A large ethnic diversity characterises the Basin's population, with Peuls, Toucouleurs, Soninkes, Malinkes, Bambaras, Wolofs and Moors. However, there is an internal migratory flow (periodic transhumance towards the pastures) and an external migratory flow towards to the cities or even outside the countries, particularly towards Europe (OMVS/SOGED 2003).

Causal chain analysis

During the period 1966 to 1970, a marked shift in the climate was observed. This gave rise to a prolonged drought characterised by a reduction in the annual rainfall and in the length of the rainy season (DaCosta 1993, Diouf 1996, Malou et al. 1998). The consequence was a reduction in river discharges as well as an invasion of seawater in all the estuaries. The mean annual discharge of Senegal River decreased from 25.9 billion m^3 for the period 1903-1967 to 13.8 billion m^3 for the period 1968-1999, indicating a trend in the reduction of stream flows since about 1967 (SGPRE/PNUE/DHI/TROPIS 2002).

The main issues addressed in the analysis of the freshwater shortage in the Senegal River Basin concern stream flow modification. In reality there are two types of modification: (i) the reduction of river discharges due to the drought, leading to an intrusion of the river by seawater; and (ii) a reduction/exclusion of seawater intrusion in the river due to damming. The first type of modification is natural, while the second one is artificial. This reduction of seawater has been superimposed on the reductions in river flow due to the drought, with the combination now characteristic of the Senegal River Delta. Therefore, the focus of the causal chain analysis will be on the damming of the River, with the drought considered as an immediate cause. Figure 12 illustrates the causal links for stream flow modification in the Senegal River Basin.

Environmental and socio-economic impacts

Reduced wetland areas (Ndiael, Djoudj) and the risk of losses in biological diversity

The persistence of the drought, the road and hydraulic infrastructure installations have resulted in a reduction in wet areas. This is accompanied by important biodiversity losses (SGPRE/PNUE/DHI/TROPIS 2002). The Ndiael reserve, classified as a Ramsar site, has been drying out, with the socio-economic and environmental consequences being vegetation degradation, wind erosion, tannes formation, reduction in biodiversity (particularly in icthyofauna and avifauna) and a loss of breeding grounds for migratory birds.

Water quality changes due to the accumulation of salt and pollutants

The deterioration of water quality becomes a problem of primary importance for the delta because of drainage from irrigated areas or water stagnation, inappropriate domestic use, the mismanagement of solid waste, the discharge of industrial waste water from Senegalese Sugar Company factory into Lake Guiers as well as the proliferation of aquatic plants. The lack of an appropriate discharge outlet in low Ferlo and a high evaporation rate has resulted in a salt accumulation in Lake Guiers. Data indicate that salt concentration in the Lake can reach as much as 40 000 tonnes per year in the Lake Guiers/low Ferlo system (SGPRE 1999). The aquatic plant proliferation has caused excessive evapotranspiration losses, which are estimated to be 3 billion m^3 per year (OMVS/SOGED 2003). Aquatic plants also constitute a tight curtain that prevents access to water uses by the population.

Reproduction areas not accessible to fish

The absence of a fish ladder in the Diama Dam and the presence of gates and embankments prevent fish from migrating to spawning areas. This contributes to the reduction of the fish population of the River. The abrupt changes of water salinity related to the discharge of the Diama Dam are often the cause of fish mortality.

Erosion and sedimentation

During the last several years, strong erosion of the banks in the Gandiolais area has been observed. There is also an accumulation of coarse sand sediments at the outlet of the River. Bank erosion is also widespread in the high river valley. Water and wind erosion are greatly accentuated in the Basin and involve the progressive degradation of the land and the loss of vegetation cover. Soil erosion and vegetation degradation in the River Basin result in run-off and the transport of sediments, and the appearance of laterite. Sediments deposited in the river outlet is one of the most frequent causes of flooding in St Louis City (SGPRE/PNUE/DHI/TROPIS 2002).

Loss of mangrove forest

Downstream from Diama, marine dynamics prevails from December to July. This increases the salinity and stresses the mangrove swamps. With the loss of mangroves, the formerly flooded mud holes gradually turn into tannes (salted soils).

Flooding of St Louis City

With the reduction in the cross-section of the river mouth due to sediments, floods have become more frequent in St Louis, most recently in 1999 and 2003. During the most recent flood in 2003, the authorities were obliged to open a channel to dump excess water into the ocean. During flood periods in St Louis there is a rise in the groundwater level mainly due to soil saturation and the stagnation of run-off. In Lake Guiers, this rise in water levels is at the origin of the destruction of the embankment and flooding of tracks, houses and irrigated perimeters.

Groundwater level rise and soil salinisation

An increase in soil salinity has been observed in some badly drained cultivated perimeters and certain wastewater discharge basins. In irrigated areas, water losses generated by less efficient irrigation practices contribute to the rise in groundwater levels. In low Ferlo, salinity can exceed 5 g/l because of industrial wastewater from the sugar factory, evaporation and lack of water circulation; this salinity makes the water quasi unusable.

Water-borne diseases

The permanent presence of standing water in the valley and the suppression of the periodic salt concentration increase favours the aquatic plants and pathogenic germs development. As a consequence, the incidence of water-borne diseases already found in the area have increased. The diseases are malaria, urinary schistosomiasis, diarrhoea, and intestinal parasitic diseases (Verhoef 1996). The delta has become a hotbed of bilharzia and prevalence rates of 80% were observed in certain villages (SGPRE 1999).

Migration due to the loss of arable land

The cultivated area experienced a notable reduction because of abandonment of certain private areas where the irrigation infrastructure was rudimentary. The deterioration of the irrigation infrastructure, soil salinisation due to the lack of drainage, and the competition from imported agricultural products (such as rice) are the causes of the abandonment of these perimeters and the associated migration of farmers to other sectors or other places (Tandia & Dieng 2001).

Reduced access for transhumant cattle farmers

There is a severe reduction in natural pasture areas due to the increase of the irrigated perimeters. In addition, access to the River became very difficult for cattle. This situation generates frequent conflicts between stockbreeders and farmers.

Reduced freshwater fishing potential

With the permanent standing freshwater, aquatic plants developed to excess and now prevent access to the water. The Cattail (*Typha australis*) constitutes a refuge and a spawning area for fish. However, the abundance of vegetation also constitutes an obstacle for fishing. In addition, infrastructure installations represent obstacles for fish migration to spawning areas.

Reduced water access

In spite of the water availability in the Basin, natural reservoirs and lakes as well as irrigated perimeters are poorly supplied because of the following factors:

- Wind erosion and sediment deposits are abundant in the delta. They limit the transport capacity of the main waterways through the formation of dikes.
- Aquatic plants form an obstacle to stream flow.
- The majority of the gates are obsolete and date back to 1940 or 1950. They were designed before the existence of the dams.
- The water intake pipe is sometimes above the actual water level.

The results are that, during high flows, certain areas are flooded and others are subjected to a severe water deficit in spite of their proximity to the River. In the estuary, marine sediment deposits represent a constraint for navigation.

Immediate causes

Reduced precipitation

The Senegal River Basin presents important climatic contrasts because of its extension between the tropical wet areas in the south and the arid areas in the north, located at the limit of the Sahara. The climate of the Basin is marked by the rhythmical movements of the Inter-Tropical Front (ITF), which separates the monsoon from the harmattan. The monsoon conveys humid air masses coming from the southwest from the anticyclone of St Helene. These humid air masses are dominants in the winter (May-June to October-November).

The season is affected when the ITF moves up north. The rainfall is very variable in the Basin, with a marked decrease towards the north (SGPRE 1994, Rochette 1975). Rainfall in the upper part of the Basin (the Guinean and Sahelian climatic domain) ranges from 1 300 to 2 000 mm per year. In the valley and the delta, which belong to the Sahelian climatic domain, annual rainfall varies from 200 to 800 mm. In dry season (November-April), the Basin is subjected to the harmattan wind, which blows from the northeast and brings hot and dry air masses. On the coast, maritime trade winds blowing from the Azores anticyclone are dominant during the winter. The reinforcement of the trade winds at the beginning of the winter induces a delay of the rainy seasons, especially in the delta. The annual rainfall is highly variable, especially in the northern part of the Basin. The coefficient of variation reaches 0.41 in Dagana, 0.19 in Kédougou and 0.25 at the center of Senegal in Bakel. The inter-annual average rainfall is 1 250 mm at Kédougou, 489 mm at Bakel and 282 mm at Dagana.

Since 1968, there is a decrease in rainfall. Figure 13 shows that the average rainfall decreased from 370 mm (1892-1967) to 238 mm (1967-2000) in St Louis (SPRE/PNUE/DHI/TROPIS 2002). The same tendency has been observed at other stations such as Dagana and Kédougou. It should be mentioned, however, that recent years have been characterised by a resumption of rainfall. For example, rainfall in St Louis exceeded 400 mm in 2000 and 1 500 mm in Kédougou in 2003.

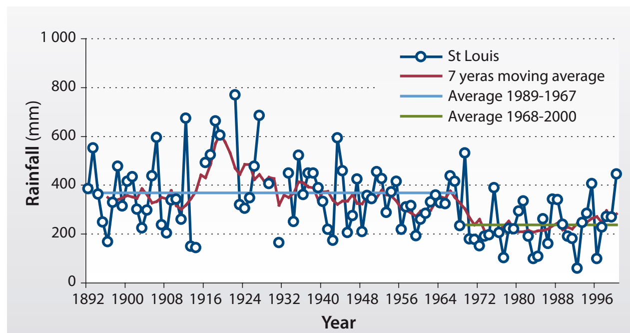

Figure 13 Annual rainfall at St Louis 1892-2000.
(Source: SGPRE/ PNUE/DHI/TROPIS 2002)

Damming and embankments

Since 1988, the Senegal River has been regulated by the Diama Dam, with its embankments, and the Manantali Dam. The Diama Dam serves to block seawater intrusion and thereby protects water and irrigation wells, and raises the level of the upstream water body, creating reserves that enable irrigation and double cropping. The Manatali Dam is supposed to attenuate extreme floods, generate electric power and store water in the wet season to augment dry-season flow for the benefit of irrigation and navigation. The water management objectives for these dams have been defined by the Standing Water Committee (Commission Permanente des Eaux, CPE). The instructions for water use are defined as satisfying the needs for various water uses while taking into account dams and population safety measures. In the rainy season, the objectives are to: (i) fill up the Manantali Dam; (ii) augment dry-season flow for the benefit of irrigation and navigation; (iii) attenuate extreme floods; and (iv) produce electrical energy. In the dry season the goal is to: (i) support and sustain low flows to allow seasonal and industrial cropping; (ii) supply drinking water for urban centres; and (iii) permit navigation from the outlet of the River to Kayes.

The blockage of salt intrusion has allowed the proliferation of aquatic plants and water-borne diseases. Recent studies undertaken by the Diama Dam Company (SOGED) show that invasive plants currently occupy 150 000 ha in the delta (OMVS/SOGED 2003). These species are mainly Cattail (*Typha australis)* and the Water salads.

Deforestation

In the Senegal River Basin, deforestation and soil degradation are major problems that tend to be widespread across the Basin. In the upper part, the valley and the delta, there is a decrease in the vegetation cover and a loss of soil fertility, often due to anthropogenic causes. The results are an increase in stream flow and sediment transport. This creates flooding problems in the villages located near river tributaries and the destruction of roads. The deforestation phenomenon is worsened by wind action, rainfall deficits, increases in salinity and the lack of drainage in the irrigated perimeters.

Sector activities

The construction of the Diama and Manantali dams on the Senegal River was designed to solve two main problems closely linked to the drought and its impacts: the availability of arable lands and water supply. The other two objectives assigned to these dams were the navigability between St Louis and Kayes and the production of hydroelectricity. Agriculture is the major sector activity of concern, followed by water supply, fluvial transport and energy production.

Agriculture

Agriculture is the main economic sector in Senegal and was for many decades characterised by a quasi monopoly for peanut production. Impacts of the drought combined with inadequate agricultural practices resulted in a general degradation of the soils, particularly in the "peanut basin" (Thiès, Diourbel, Kaolack and Fatick regions). The persistence of the drought weakened peanut production, which is solely dependent on rainfall. In the river valley, agriculture practiced mainly in flood prone areas ("waalo"), was compromised as a result of the decrease in the river discharge (Olivry 1983, Handschumacher et al. 1992). In the Senegal River Basin, it is estimated that 400 000 ha of soils were affected by salinisation (Sadio 1991). Consequently, it was decided to build the Diama and Manantali dams.

One of the objectives of the Senegal River damming was to allow the development of irrigated crops, particularly rice. In 1987 (before the damming of the river) irrigated areas covered almost 40 000 ha, located mainly in the delta and the low valley, with another 2 700 ha in the area of Lake R'kiz (OMVS 2000). Recession flood farming areas in the River Basin are shown in Table 23.

Table 23 Recession flood farming area in the Senegal Basin in 1987 before the damming of the River.

Areas	Flooded area (ha)	Cultivated area (ha)	Collected area (ha)
Left bank	31 000	20 150	18 780
Right bank	27 000	19 170	17 200
Upper part	4 500	1 125	810
Senegal River Basin	62 500	40 445	36 790

(Source: OMVS 2000)

It well recognised that the damming increased the availability of water in the Basin. However, agriculture in the valley is currently faced with many problems, and the benefits from the dam are below expectation. This situation resulted mainly from the limited financial capacity of poorer residents, for whom the equipment investment is too costly. Rice production decreased from 130 600 tonnes in 1994 to 85 300 tonnes in 1996. According to Devey (1997), this is due essentially to the fact that the rice produced locally is less competitive with imported rice. Other difficulties are:

- The rate of irrigation infrastructure installation is low and does not reach 2 000 ha per year.
- Crops produced (rice and onions) does not adequately meet food needs and must be supplemented with imports.
- The lack of professionalism and the low quality of the irrigation infrastructure.

The development of the irrigated area since 1975 in the Senegal River Basin is illustrated in Figure 14. Long-term projections are: 98 000 ha for Senegal in year 2010, 73 377 ha for Mauritania in year 2017 and 14 500 ha for Mali in year 2025 (OMVS 2000).

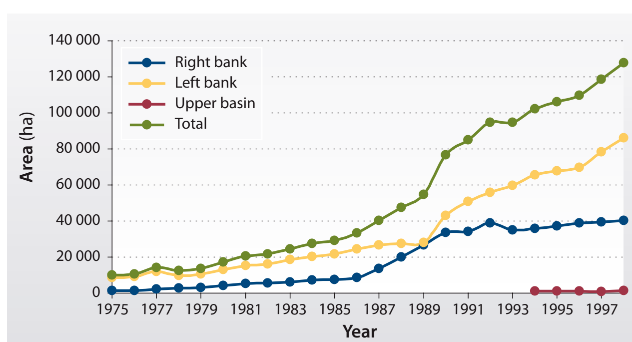

Figure 14 Irrigated area in the Senegal River Basin 1975-1998.
(Source: OMVS 2000)

Water supply

The second main objective of the Diama Dam was to ensure a water supply, especially for Dakar. Lake Guiers, with the Ngnith station pumps, provides a drinking water volume of 64 000 m^3 per day for the city of Dakar. The construction of a new water treatment plant at Keur Momar Sarr in the southern Lake Guiers is planned within the framework of the Long Term Water Project. The treatment plant is expected to provide an additional volume of 65 000 m^3/day during the first phase of the project (2003-2007) and 135 000 m^3 per day in the second phase (after 2008).

This increase in water supply volume will make it possible to stop the overexploitation of groundwater resources of Dakar and Thiès. It is also expected that 85% of water supply for the city of Nouakchott in Mauritania will be provided by the Senegal River, with the remaining 15% provided by the Trarza aquifer.

On the right bank of the River, the annual water supply production for Rosso in 1999 was 584 000 m^3, with a monthly average volume of 48 600 m^3. In the same year on the left bank of the River, the private Water Supply Company (Sénégalaise des Eaux, SDE) supplied a total of more than 27.5 million m^3 of drinking water for St Louis, Richard Toll, Dagana, Podor, Matam and Bakel. In the Malian part of the upper Senegal River Basin, the drinking water supply volume was close to 2.7 million m^3 in 1999.

In 1999, the total drinking water supply for the population in the River Basin was 2.63 m^3/s and it is expected to triple (7.03 m^3/s) in year 2025 (OMVS 2000) (Table 24). The industrial water supply demand for the Senegal River Basin is about 6 888 km^3 per year (Table 25). The main industrial companies are: the Senegalese Sugar Company (CSS), the Senegalese Canned Food company (SOCAS) located on the left bank, and the gold mining Company of Sadiola (SEMOS) in Mali.

Navigation

Another objective of the dams was to ensure the navigability of the River between its mouth and Kayes (940 km upstream in Mali). The continuous decrease in the river discharge has considerably reduced the use of the Senegal River for transport and trade since 1972. The establishment of a stable river discharge (227 m^3/s) in Bakel allows the resurgence of this activity. Actually, the Organisation for the Development of the Senegal River Basin (OMVS) is in charge of the navigability between St. Louis and Kayes while Senegalese council of shippers (COSEC) will consider the building of a new harbour in St Louis as well an access from the sea. A feasibility study was begun in 2001 (Niang-Diop et al. 2002).

Table 24 Drinking water needs in the Senegal River Basin.

Area	1999		2010		2025	
	m^3/s	m^3/day	m^3/s	m^3/day	m^3/s	m^3/day
Dakar	0.76	64 000	2.38	199 000	2.35	199 000
Nouakchott	ND	ND	0.99	84 150	1.91	161 500
Urban centres	1.18	99 491	1.31	110 999	1.52	128 866
Other areas	0.69	58 649	0.87	73 971	1.25	105 725
Total	2.63	222 140	5.55	468 120	7.03	59 091

ND = No Data.

(Source: OMVS 2000)

Table 25 Industrial water needs in Senegal River Basin.

Company	Water needs (km^3)
Senegalese Sugar Company (CSS)	549
Gold mining Company of Sadiola in Mali (SEMOS)	5 790
Senegalese canning food Company (SOCAS)	549
Total	6 888

(Source: OMVS 2000)

Energy production

Forest product ; either firewood, 1.5 million tonnes, or charcoal, 330 000 tonnes per year, provide 61% of the energy used in Senegal, followed by imported petroleum (37%). As early as 1981, new strategies have been developed to try to change this energy consumption pattern (Devey 1997). The construction of the Manantali Dam is a part of this strategy. It allows the production of 800 GWh per year of hydroelectricity. This production is not totally consumed. Since 2001, the difference is restored to the downstream of the dam to be used for other needs.

Root causes

Demographic growth, urbanisation and poverty

The population in the Senegal River Basin was 1.55 million inhabitants in 1988 and approximately 2 million inhabitants in 2000 (OMVS/SOGED 2003). This population exerts a pressure either directly on water resources of the Basin or indirectly in terms of the search for income. Another problem linked to demographic growth is poverty that aggravates the negative impacts of the population pressure.

The population growth resulted in a high water demand for different uses and an increase in water pollution. In addition, there is an uncontrolled expansion of urban areas, which are generally established in the riverbed, which results in a reduction of the River's cross-section and more frequent flooding. The urbanisation rate increased from

23% in 1960 to 39% in 1988 and 41.2% in 1996. In Dakar, for example, population density increased considerably, from 930 inhabitans/km^2 in 1960 to 2 730 in 1988 and 4 081 in 1999. This rapid growth of Dakar and other major cities is due to a high natural fertility rate and the important migratory fluxes that have been exacerbated by the drought.

Poverty is a critical problem for the populations and communities of the Basin. This is represented by of the root causes of poor quality water resources infrastructure installations, inappropriate or even the lack of drainage control design in the irrigated perimeters, and the lack of adequate drinking water systems. The population of the Basin is primarily rural with a relatively low income that does not allow for investments that would result in a better life.

Lack of appropriate governance

The lack of appropriate governance is manifested by the lack of enforcement of regulations, the absence of an adequate institutional setting and the absence of democracy, which means that stakeholders cannot participate in decision-making and are not held accountable for their actions. In many cases, powerless and unwilling partners endure decisions that are often dictated by powerful economic operators. Problems related to the lack of appropriate governance and the institutional setting are well identified and are well known, particularly the insufficiency or the absence of the organisation and location of activities that are the source of many conflicts concerning the water resources use and the deterioration of living conditions.

The institutional setting is less efficient because of the rapid changes in institutions, stakeholders and the division of power. Projects and decisions are often taken without taking into account the opinion of the others. Lack of appropriate governance is also illustrated by the numerous problems related to information; the absence of any circulation of information, the deficiency at times in the quality of information, the insufficiency of the sensitisation to environmental degradation and the lack of environmental education (SGPRE/PNUE/DHI/TROPIS 2002).

Illiteracy and the lack of appropriate environmental education are also causes of water pollution. This is reflected by poor agricultural practices; for example, in certain irrigated perimeters, polluted drained water is discharged directly into freshwater. The Senegalese Sugar Company and the neighbouring irrigated perimeters are discharging polluted water into Lake Guiers, the Ndiael, and the Senegal River. Data indicates that the Senegalese Sugar Company is discharging the equivalent of 40 000 tonnes of salt per year in Lake Guiers (SGPRE 1999). The population in the neighbouring localities is not always aware of the dangers represented by the pollution, the mismanagement of solid waste and the direct use of untreated raw water for domestic and purposes.

Inefficient irrigation technology

Irrigation water use efficiency is very low. In some irrigated perimeters in the river valley, water use efficiency is quite often lower than 50%, particularly in those areas cultivated in rice and market gardening crops, where furrow irrigation is practiced. This is linked to the lack of farmer education or insufficient financial resources for install appropriate irrigation systems. The main water supply pipes are not well maintained. In many cases, drainage systems are not taken into account. Consequently, several pollution problems are observed in the region such as the pollution of Lake Guiers and the drainage of the SAED perimeter in the Ndiael.

Natural causes

The stream flow in the Senegal River is strongly related to rainfall. For the period 1904-1999, the mean annual flow volume was 22.1 billion m^3 at Bakel (SGPRE 1999). The maximum and the minimum volume observed were 42 billion m^3 (1924) and 6.5 billion m^3 (1984) respectively. The average stream flow volume at Bakel decreased from 25.9 billion m^3 (1904-1967) to 13.78 billion m^3 (1967-1999) (SGPRE 1999).

Lowering of the water table – Souss-Massa River Basin

In Morocco, the consequences of increased industrialisation and a rapidly growing population have accentuated the growth in demands for water resources and have promoted their intensive use. For the last three decades the emphasis was on maximising the capture of Morocco's surface water resources for irrigated agriculture, potable water supplies, industrialisation and energy generation. Important infrastructure to capture and use about two-thirds of surface water is already in place, and a number infrastructure projects are in advanced stages of planning and construction to capture most of the remaining potential.

Despite remarkable achievements, Morocco faces growing challenges in the water sector. One of the major issues is the decline in water resources. The mean annual rainfall is 150 billion m^3 but the renewable water resources do not exceed 29 billion m^3. Taking into account potential storage sites and groundwater development possibilities, only 20 billion m^3 are divertible. A number of river basins are already experiencing water shortages, which will impose costly interbasin transfers. Some of the more intensively used aquifers are now considered to be under stress with serious drawdowns and saltwater intrusion in the coastal ones. This is the case of the Souss aquifer in the Souss-Massa Basin (Ait Kadi 2002).

The focus of the causal chain analysis is to determine the source, the underlying constraints and the root causes of the shortage of freshwater in this region. The reasoning behind the choice of focusing the causal chain analysis on freshwater shortages can be argued in view of the observed trends in water table depletion in the whole region and the need to address the issue of water shortage to prevent further environmental deterioration. The underlying characteristics and assumptions of the water table depletion problem are summarised below:

- Recent problematic trends in the water balance of the Souss aquifer;
- Increased agricultural water demand;
- Increased non-agricultural water demand;
- Unsustainable water table drawdown.

System description

The Souss River Basin covers approximately 27 000 km^2. It is located at the southern end of the Atlas Mountains. It is bounded on the north by the High Atlas Mountains and on the south by the Anti Atlas Mountains (Figure 5 in Regional definition). The two mountains ranges joint at Mount Siroua (3 304 m above sea level) to form the drainage divide between the Souss-Massa Basin to the west and the Draa Basin to the east. The River Basin encompasses the Souss River, the Massa River and the coastal river basins of Tamri and Tamraght, all of which discharge into the Atlantic Ocean. In 1994, the population in the Basin was 1 541 000 inhabitants.

The land use in general is dominated by forest (48%), pasture land (33%) and arable land (19%) (Baroud 2002). The potential irrigated area is 250 000 ha, with 134 295 ha currently under irrigation. Citrus and vegetables represent 44% of crops grown in the irrigated area (Table 26). With a year-round growing season, irrigation from reservoirs and groundwater enables the region to produce more than 60% of Morocco's agricultural exports (mostly citrus and tomatoes), but the overdrawn aquifer is falling by more than 1.5 m per year in some areas (Rhodes 1999).

Table 26 Irrigated crops in Souss-Massa River Basin.

Crop	Irrigated area* (%)
Citrus	27
Vegetables	17
Cereals	17
Olive tree	17
Fodders	10
Banana	2
Others	10
Total	100

*Note: * During a normal year.*
(Source: Baroud 2002)

The region is arid to semi-arid, and receives 270 mm of rain in an average year. The Souss and Massa rivers are the primary sources of surface water in the area. The normally available surface water each year ranges from 341 to 635 million m^3, but it can drop as low as 35 million m^3 in dry years, as it did in 1960-1961, and as high as 2 160 million m^3 (1962-1963). Surface water is collected and stored in seven reservoirs with a total storage capacity of more than 750 million m^3 (CSEC 2001) (Table 27). Groundwater is obtained from two major aquifers (DGH 1999):

- The Souss aquifer, limited to the north by the High Atlas Mountains and to the south by the Anti-Atlas Mountains and to the west by

Table 27 Dams in Souss River Basin.

Dam	Storage capacity (million m³)	Use
Youssef Ben Tachefine	303	Irrigation and drinking water
Abdelmoumen	214	Irrigation and drinking water
Aoulouz	110	Groundwater recharge
Med Mokhtar Soussi	50	Irrigation
Imin El Kheng	12	Irrigation and groundwater recharge
Moulay Abdellah	110	No data
Total	799	

(Source: CSEC 2001)

the Atlantic Ocean and covers 4 150 km². Its capacity is estimated to be 30 billion m³ with a depth ranging form 150 m to 500 m;

- The Chtoukas aquifer, which is located south west of the Souss valley and covers an area of 940 km². Its estimated capacity is 1 billion m³ with a depth ranging from 50 to 300 m.

Even though the Souss-Massa Basin is located entirely in Morocco, there are several tranboundary issues that are relevant for this report: (i) a significant portion of the available water resources of the Souss-Massa Basin can be lost to the Atlantic Ocean when a strong flash flood occurs; (ii) a large proportion (roughly 60%) of the national production of fresh fruits and vegetables that are exported from Morocco to international markets originates in the Basin; (iii) a correspondingly large amount of 'virtual water' is exported annually through the export of commercial high-cash crop commodities; and (iv) an equally important amount of irrigation water is currently pumped from the transboundary aquifer, around two-thirds of the total water used for irrigation purposes.

Despite the water scarcity in the region, the international character of the Souss-Massa Basin is reflected in the level of export of what is known as 'virtual water'. This refers to the volume of water contained in commodities that are exported, both food and non-food. For example, as 1 tonnes of tomato production is approximately between 80 and 90% of water by weight, the export of 195 000 tonnes of Moroccan tomatoes to Europe in 2001 would correspond to the export of 165 750 tonnes of water, of which 60% were produced in the Souss-Massa Basin. The figure is even higher when considering the total export of fruits and vegetables from this region, totaling about 380 000 tonnes or an export equivalent of 323 000 tonnes of virtual water during the same year (MCE 2001). Over the last decade, total export of fruits and vegetables from the region to the international market varied between 257 570 tonnes in 1996 to 456 723 tonnes in 1999, demonstrating a large inter-annual variability (Figure 15).

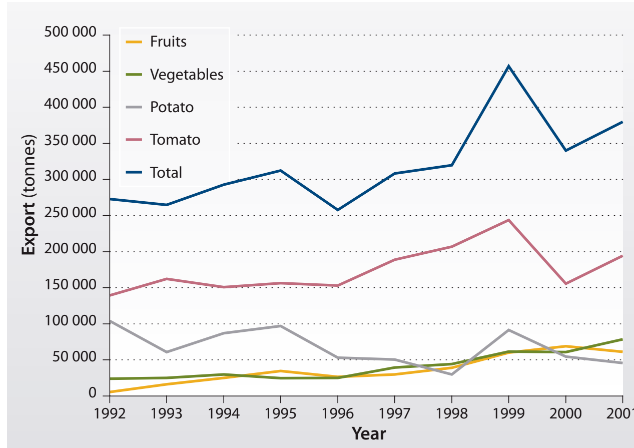

Figure 15 Export of fruits and vegetables in the Souss-Massa River Basin.
(Source: MCE 2001)

The region is one of the most water-poor regions in the world and significant efforts are being made to improve the management of water resources. Although there is still room for further progress, particularly regarding irrigation efficiency, the region appears to be structurally unable to feed its increasing population and will probably need to rely more and more on virtual water, such as food imports, mainly in the form of grain cereals.

Causal chain analysis

In recent years, agriculture has developed in the central plain of Souss-Massa River Basin, in spite of the natural dryness of the soil. Nevertheless, agriculture is not a new economic activity in the area. Traditionally, water for irrigation was obtained by digging almost horizontal galleries to the groundwater table, and then letting the water flow by gravity down the gallery. At present, water is pumped from the subsurface. For the last three or four decades pumping has depleted the water table. In some places, the aquifer drawdown can be as high as 2 m per year and has ranged between 10 to 65 m since 1970 (CSEC 2001). Along with increasing pumping costs to a considerable degree, the lowering of the water table means that the system will reach a point where the availability of water will not meet the demand. In addition, the high evaporation and infiltration rates in the central plain means that rivers in the Basin tend to dry up before reaching the main stream. In general, run-off occurs only after consecutive rainy days and, mostly, the horizontal movement of water takes place in the deep groundwater system.

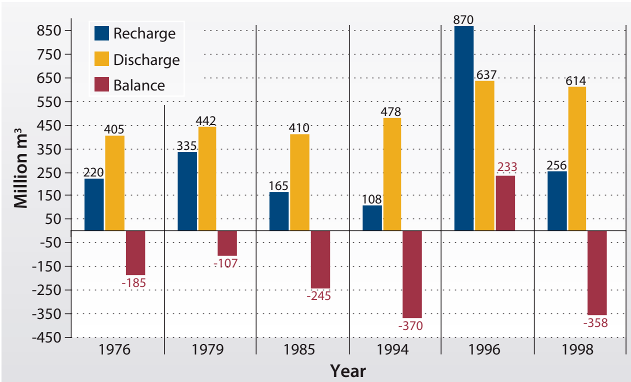

Figure 16 Groundwater balance in the Souss River Basin.
(Source: DGH 1999)

Intensive irrigation development, urban and industrial growth, and the expansion of the tourist industry are making increasingly heavy demands on the area's water resources. The situation is worsened by the Basin's arid ecological conditions. The region is therefore experiencing chronic water deficits.

Evidence based on existing meteorological and hydrological records clearly indicates that the impacts of freshwater shortages are becoming more and more acute in the Souss-Massa region. Figure 16 provides a good illustration of recent trends in the water balance deterioration.

The impacts are most severe during the dry season, which lasts for at least six months each year, and the situation is further complicated by the frequent occurrence of drought episodes in Morocco as a whole and in the region in particular. While the freshwater shortage creates periodic water scarcity, which in time will become more acute due to the increases in water demand (population growth, tourism, industrial activities), the additional water shortages created by droughts will be more frequent and more widespread as the region's water utilisation rate increases.

Therefore, management of the freshwater shortage in the Souss aquifer is not only a major environmental concern; but it is also a crucial problem for the local community's well being. Furthermore, it is indeed a severe constraint for future development of commercial agriculture and tourism industry, the two most important sources of revenue in the region.

The main issues addressed in the analysis of the freshwater shortage in the Souss-Massa Basin concerned the lowering of water table level and the rapid depletion of underground water resources and the modification of stream flow in the River (Figure 17). The changes in water table may be considered as part of a global change that is occurring in the whole region, as described under the Global change concern. However, the lowering of water table is considered to be more critical in the context of the Souss-Massa Basin than the modification of stream flow. Therefore, the focus of the causal chain analysis has been placed on the underground water table depletion issue (DGH 1999).

Immediate causes

The immediate causes underlying the stream flow modification problem are associated with decreased input, drop in annual rainfall patterns and decreased inflow. These may be considered a part of the global change described earlier.

Excessive pumping

The drop in the water table has mainly resulted from excessive pumping for agricultural irrigation purposes and from reduced recharge. The evidence for excessive underground water pumping is reflected in the fact that out of 918 million m^3 of water that is used

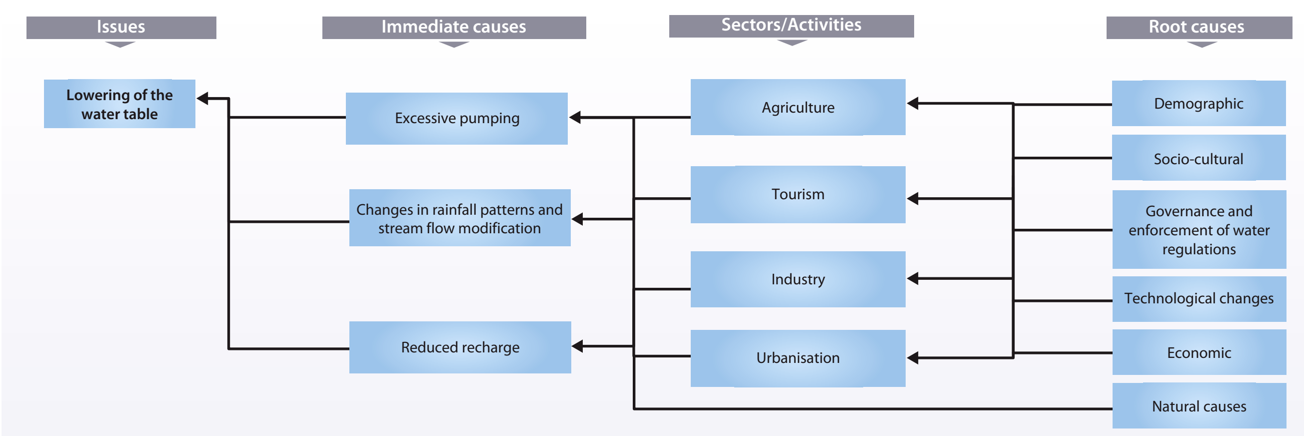

Figure 17 Causal chain diagram illustrating the causal links for lowering of the water table in the Souss-Massa River Basin.

annually, 618 million m^3, or 67% of the total volume, is withdrawn from the groundwater (CSEC 2001). Groundwater, which is the major water source for the region, is obtained primarily from the alluvium in the Souss-Massa valley. In 2002, more than 13 000 wells were used to withdraw groundwater for domestic, industrial, and agricultural uses. The number of wells has rapidly increased with the more frequent drought episodes experienced in the region over the past two decades. Generally, the water quality in the alluvium is good, with most wells producing fairly good quality water. Some wells, however, show deteriorated water quality.

Changes in rainfall patterns and stream flow modification

The excessive pumping is exacerbated by low and variable rainfall and surface water. Rainfall in the Basin is highly variable and averages 280 mm per year in the northeast Souss Valley and 265 mm per year in the southwest area of the valley. The Souss River, the main river in the basin, is characterised by an irregular flow and frequently dries up for as many as 310 days per year. During the last 80 years, Morocco in general and the Souss-Massa River Basin in particular experienced 27 years of drought recurring at a three-year interval (Swearingen & Bencherifa 1996). Prior to the construction of major dams, groundwater was the only source of water for irrigation during the dry periods.

Reduced recharge

The reduced recharge of the Souss aquifer is illustrated in Figure 16 above. The evidence for this problem is also reflected in the inter-annual variation of the depth of water table over the period 1969-1999, as shown in Figure 18. The data indicate that the deficit ranges from -185 million m^3 in 1976 to -358 million m^3 in 1996 and that the water table level dropped from -15 m in 1969 to -35 m in 1999 with an

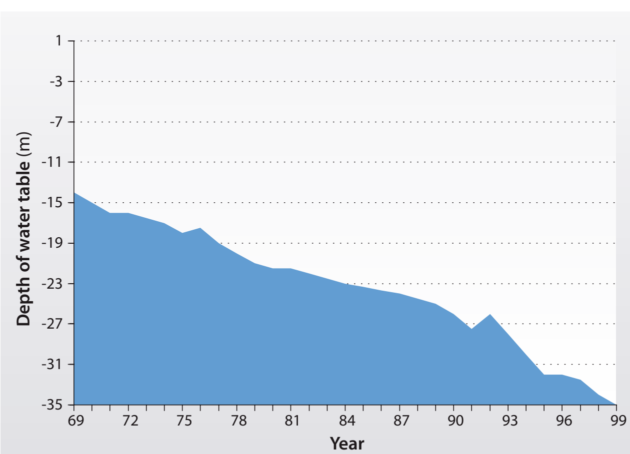

Figure 18 Inter-annual variation in the water table depth in the Souss aquifer.
(Source: DGH 1999)

average drawdown of 0.8 m/year and a maximum of 1.5 m/year for 1990 and 1997. The low rate of renewable groundwater (0.29 billion m^3) exacerbates the reduced recharge problem, which is further aggravated by run-off losses (DGH 1999).

Sector activities

The main sector activities that generate freshwater shortages in the Souss-Massa Basin are associated with the allocation of water resources for: irrigated agriculture, tourism and industrial activities, and urbanisation.

Table 28 Water demand by sector in the Souss Massa Basin.

Sector		Water demand (million m^3)		
		1993	2000	2020*
Agricultural sector	Total	915	1 005	1 075
	Surface water	300	315	315
	Groundwater	615	690	760
Non-agricultural sector		ND	50.8	88.6

*Note: ND = No Data. * Projected demand.*
(Source: CSEC 2001)

The water demand by sector is summarised in Table 28. The data indicate that through the sustained effort of water mobilisation in the Souss-Massa Basin, about 1 056 million m^3 were regulated in 2000 and about 690 million m^3 were extracted from aquifers, making roughly 1 005 million m^3 available for irrigation, and the remaining 51 million m^3 for tourism, industrial and domestic water (CSEC 2001). It is worth noting the steady increase in water demand by sector and the corresponding projected figures for 2020, which predicts the levels will reach 1 075 million m^3 for agriculture and 88.6 million m^3 for the non-agricultural sector. The resulting consequences of the increasing water demand in both agricultural and non-agricultural sector activities have led to a major deterioration of the groundwater balance to meet the growing needs.

Irrigated agriculture

In terms of water use, irrigated agriculture is the main user of the available water in the region, as is the case for the whole of Morocco. In 2000, only 51 million m^3 were allocated to industrial activities and domestic water, making the agricultural water sector consumption at around 95% of the total available water in the region (CSEC 2001).

The increased agricultural water demand in the Souss-Massa region resulted from a steady increase in irrigated acreages over the past three decades. The recent figures indicate that total irrigated area increased from 134 295 ha in 1993 to 140 455 ha in 2000; the projected increase by 2020 is 150 000 ha (CSEC 2001). Changes in the cropping

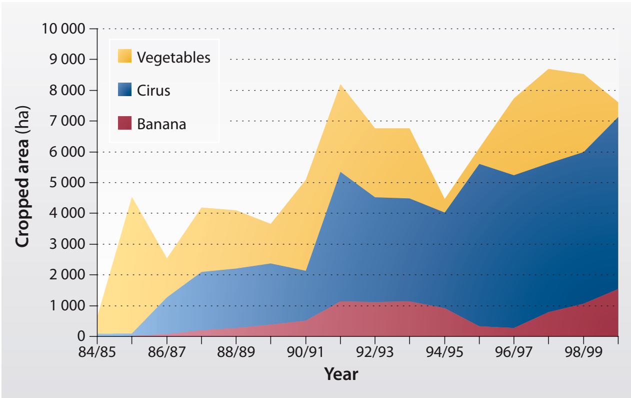

Figure 19 Cropped area for irrigated cash crops in the Souss-Massa River Basin.
(Source: CSEC 2001)

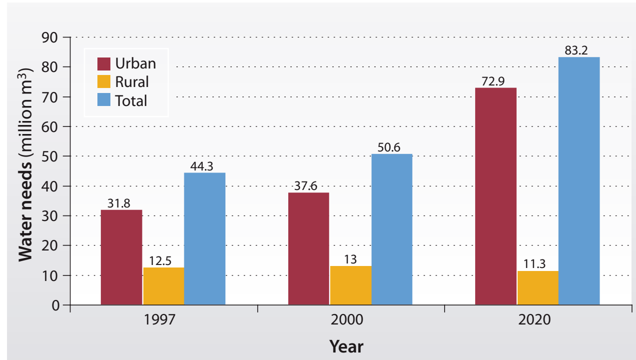

Figure 20 Present and projected domestic water needs in the Souss-Massa River Basin.
(Source: CSESC 2001)

patterns for the last three decades have also contributed through the introduction of new high-water-demand cash crops such as bananas, along with the development of the vegetable crop for export (Figure 19).

The water losses through evaporation associated with the use of traditional open irrigation canals, and the limited maintenance of the water transport system through the canals also explain the increased agricultural water demand observed in the region. However, the predominance of inefficient traditional irrigation systems, comprised of 50% flood irrigation and 28% sprinkler irrigation, represents the main reason for the 40 to 50% water use efficiency index observed in the region (Kent & Ouattar 2002).

Tourism, industry and urbanisation

In parallel with the steady increase in the agricultural water demand, the non-agricultural water demand is also rapidly increasing as a result of demographic pressure, an improving standard of living, urbanisation and the development of tourism and other industrial activities. Presently, it is estimated that almost 60% of the potable water supply in the Agadir area comes from groundwater wells and 40% from surface water reservoirs (Kent & Ouattar 2002). Figure 20 documents such development and indicates an alarming projected water demand by 2020 on the order of 83 million m^3. Fully 86% of this demand would be allocated to meet urbanisation needs.

Root causes

Demographic

In 1971, the population of the Souss-Massa River Basin was 938 000 inhabitants (about 6.1% of the total population of Morocco). In 1994, the population had grown to 1 541 000 inhabitants and is expected almost to double by the year 2020 (CSEC 2001) (Figure 21). The region's population is equally divided between rural and urban settlements. Urban populations have grown enormously in the past decade, as drought has pushed people out of subsistence farming, and economic opportunities have pulled people into towns where there is at least seasonal work in export agriculture, tourism, fishing, and transportation.

The estimated water demand for domestic use, which is currently about 75 liters per capita per day, is expected to increase to 120-160 liters per capita per day by the year 2020 (Reiss & Ouattar 2002). A comparatively much higher water demand is expected to apply to the tourism industry, as in 2002 it already ranged from 450 to 1 600 liters per capita per day in some hotels in Agadir. The corresponding total water demand would total 83.2 million m^3.

Socio-cultural

In Morocco, water is traditionally considered a free public resource. This inevitably influences the enforcement of regulations. The Moroccan government effectively has total rights to all of the country's water and in 1995 passed a law authorising the management of the country's

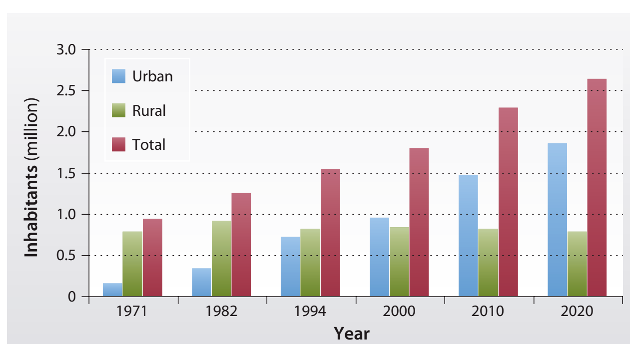

Figure 21 Population in Souss -Massa River Basin.
(Source: CSEC 2001)

water at the basin level. This law, when fully implemented, will result in a more decentralised and participatory process for water management. The newly established Souss-Massa River Basin Agency must work with five major public existing organisations currently operating in the water sector: irrigation, potable water, environment and health, in addition to water user associations (see Root cause: Governance and enforcement of water regulations below).

Historically, water rights and water management issues have been handled by local communities that are located in traditional irrigation zones. The modern legislation applies to large, commercial irrigation areas, which have developed during the past 30 years. The Moroccan legal system includes a mixture of community, Islamic and newly developed water rights and rules from the 1995 Water Law, which now constitutes the main legal context for water management, rights and use. The law recognises that all water resources are a public good and that water should be managed at a river basin level.

Governance and enforcement of water regulations

In Morocco, several active institutional bodies intervene to one extent or another in water management at the local, regional and national levels. These include:

- The High Council for Water and Climate (Conseil Supèrieur de l'Eau et du Climat, CSEC) is a national consultative body that approves national and regional water resource master plans.
- The Irrigation Agency (Office Regional de Mise en Valeur Agricole de Souss Massa, ORVASM), responsible for irrigation perimeters, planning and construction of irrigation canals and transporting water from reservoirs to farmers. It has also drilled numerous irrigation wells used for irrigation. In the absence of a Water User Association, it collects money directly from farmers for operation and maintenance of the irrigation system, but capital costs are not recovered.
- The Souss-Massa River Basin Agency (Agence Régionale de Bassin, RBA) was created recently and is responsible for reservoirs and hydraulic infrastructure maintenance and for upgrading regional master plans and planning for the use of water resources in the basin, including groundwater. In addition it coordinates water management committees at the basin level.
- The Drinking Water Agency (Office National de l'Eau Potable, ONEP)provides wholesale water to the Agadir Municipal Authority and directly to other small towns and villages in the area.
- The Agadir Municipal Authority (Régie Autonome Multi Service d'Agadir, RAMSA) is an autonomous state-controlled water utility company that distributes and sells drinking water to Agadir.
- Water User Associations (Association des Usagers d 'Eau Agricole, AUEA) have been created to take over operation and maintenance responsibilities, and charge each farmer for water that is used to maintain the distribution systems. If user groups have not been formed, the Regional Agricultural Development Authority (Offices Régionaux de Mise en Valeur Agricole, ORMVA) collects money directly from the farmers for operation and maintenance of the distribution system.

The revision of the Moroccan Water Law in 1995 introduced many new considerations about the management of water at the national and local level. One of the important aspects is the official recognition of planning by the state of water mobilisation and allocation as the main instrument for decision-making about public infrastructure, water allocation and water transfer. The Water Basin Plan is to be prepared by the Regional Basin Agency (RBA) and to be submitted to the High Council for Water and Climate (CSEC) in order to adopt it formally. Once adopted, the master plan, which is comprised of an integrated management of water resource at the hydrological basin level, is the main document for the support of intersectoral water allocation, extraction agreements and concessions. It also includes goals in terms of quality (CSEC 2001).

A number of new tools have been implemented to enforce the new water management rules. These include:

- The introduction of the Regional Basin Agency, as the main entity in charge of water issues at the water basin level.
- The introduction of new taxes, (River Basin recovering tax) based on extraction and pollution levels.
- The formal introduction of the National Hydrological Plan as the main tool for solving allocation conflicts.
- The introduction of new instruments to deal with pollution and drought; specifically fees for polluters, subsidies for investments to reduce pollution and new powers so that the administration can deal with drought.

However, more time is needed for the 1995 Water Law prescriptions to come into force, and presently the decision-making process is highly concentrated, which results in poor enforcement of regulations. The fact that a ministerial department (the Secretary of State for Water) is entirely devoted to water issues may help speed up the implementation of the Water Law principles in practice, and yield a more comprehensive package for water management, including enforcement of regulations.

Technological changes

Inefficient irrigation systems

In spite of the fact that the Souss-Massa region is technologically more advanced than the rest of Morocco, most of the land is still under flood irrigation. Flood irrigation still covers almost 50% of irrigated land, sprinkler irrigation is used on another 28%, and drip and irrigation covers only 25% of all irrigated agricultural land in the Souss River Basin (Kent & Ouattar 2002). Thus, water-saving technologies have been slow to reach farmers. The region invested heavily in mobilising and managing the water supply at macro-scale level, and little attention was devoted to saving water and improving water demand management. Water-savings data indicates that global water losses at the farm level as well as in the irrigation systems range from 45% to 95% with an average of 69% for the period 1987-1999 (Tayaa 2002) (Figure 22).

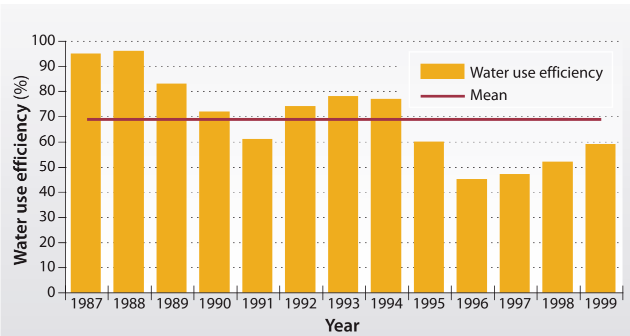

Figure 22 Irrigation water use efficiency in the Souss Massa River Basin.
(Source:Tayaa 2002)

Inappropriate well technologies

The lowering of the groundwater table is further complicated by the use of inappropriate well digging technologies, which are similar to that used by commercial oil prospecting companies. The policies thus far implemented have failed to provide local farming communities the necessary incentives to participate in responsible water management decisions. This is true both from the perspective of technology use and water pricing.

Economic

The economic root causes elaborated in this section include water pricing policies, water market failures and distortions due to subsidies, and users' behaviors and attitudes. There is a great paradox regarding the economics of the freshwater shortage issues in the Souss-Massa Basin and in Morocco as a whole. On the one hand, low-priced water provides little incentive for farmers to invest in water-saving technologies such as drip irrigation. Instead, it encourages farmers to overuse water, thereby exacerbating the problems of decreases in the groundwater table, with associated waterlogging and salinity problems. On the other hand, sustainability of the irrigation systems is at stake: at present, water for irrigation is practically free, mainly because a large number of farmers cannot afford to pay water charges, even to cover the operating and maintenance costs. There are also social and cultural obstacles to charging a fee for water for irrigation and even for other uses.

This is why the policies initially implemented overemphasised irrigation subsidies. The effective rate of subsidies for investment was as high as 95% for small farms, which represent the majority of the farming community. Although the subsidy rate was revised to 40% in 1984, most exemptions were maintained and only 10% of the investment cost was included in water rate charges. In 1996, following the 1995 Water Law, all exemptions have been cancelled and the 40% subsidy is to be recovered independently of water rate charges (BenAberrazik 2002).

The average urban charge for water in Agadir is 0.24 USD per m^3 for users consuming less than 24 m^3 per month and 0.76 USD per m^3 for those consuming more than 60 m^3 per month (Kent & Ouattar 2002). The average charge for irrigation water is approximately 0.052 USD per m^3. Because neither urban nor irrigation rates include the capital cost of construction of dams, urban charges frequently cover only 50% of the full cost of water and irrigation charges less than 10% of the full cost of water. Private well owners do not currently pay for water. When the 1995 Water Law becomes fully implemented, it will allow the Souss-Massa Basin Agency to charge approximately 0.002 USD per m^3 for groundwater pumped from private wells. Therefore, water pricing is still not sufficiently compelling to stimulate water savings. In fact water distributed to farmers within the irrigated Massa perimeter is priced at half its real distribution cost (0.052 USD per m^3 paid by farmers, as compared to 0.123 USD per m^3 for the estimated operation and maintenance cost). If we include the investment cost, the difference between the price paid and the real cost is even higher. Investment costs are still supported by government budgets. Pricing reform, implemented during the last years, which aims at increasing gradually water irrigation prices, has been slow to achieve its goals. Improving water allocation efficiency, via water pricing, is still considered an important strategic objective.

Natural causes

Rainfall in the Souss-Massa Basin is highly variable and the Souss River is characterised by an irregular flow and frequently dries up. During the last 80 years, the River Basin has experienced 27 years of drought, recurring at a three-years interval (Swearingen & Bencherifa 1996).

Overexploitation of fish – Canary Current

At least seven of the countries in Canary Current region, Morocco, Mauritania, Senegal, Cape Verde, The Gambia, Guinea, and Guinea-Bissau, as well as the Canary Islands, are coastal states bordering the Atlantic Ocean and have important marine fisheries stocks. Generally, the marine fisheries of the region consist of two sub-sectors, industrial and artisanal, which target pelagic and demersal stocks. These stocks constitute, for the states, vital renewable natural resources that provide food and income for local populations, foreign exchange earnings, revenue for the national governments (balance of payments) and employment opportunities. Throughout the region, local populations are engage in artisanal fishing, whereas exploitation at the industrial level is dominated by fleets of vessels, equipped with ultra efficient state-of-the-art fish detection and capture equipment.

The fisheries sector, which is vital for social stability and the survival of local populations, is threatened by destructive, unsustainable fishing methods and practices, ever-increasing fishing effort without due consideration of the ability of the resources to support the exploitation. This results in overexploitation, excessive by-catches of non-target organisms, including endangered and protected species, and discards.

The efforts of the states of the region to develop and to use these fish stocks in a sustainable manner are limited by the lack of adequate skilled manpower and financial and material resources. Furthermore, the poor and precarious state of their national economies compel these countries to grant fishing access rights to vessels, the majority of them foreign-owned, at a level that exceeds sustainable harvesting. This has resulted in the overexploitation of several stocks such as shrimps, cephalopods, demersal and pelagic fishes, and other aquatic organisms. Another constraint is that the existing fisheries resources management regime grants little power to local communities in decision-making regarding allocation of fishing access rights.

System description

Marine fisheries of the region

Generally, the marine fisheries sector in the region is characterised by operations at industrial and artisanal levels, with the industrial sub-sector being distinguished by large-scale investment in export oriented production. Investment in the artisanal sub-sector is relatively small, with fisherfolk operating from many dispersed, and often isolated, landing sites. Most of the industrial vessels are large, off-shore and foreign-owned while the artisanal vessels are locally built wooden canoes. Senegalese artisanal fishermen dominate fishing in the region because of their recognised fishing skills and willingness to migrate along the entire marine coastline from Mauritania in the north to Guinea in the south.

Fisheries resources potentials

The marine zone of the region is characterised by a high biological diversity and significant fisheries resources. Generally, the fish stocks that are exploited in the region can be divided into two main groups; pelagics and demersals species.

In Senegal, the resources are further characterised by two major groups; offshore and coastal pelagic resources, and deep sea and coastal demersal resources. The Republic of Cape Verde, off the coast of Senegal, has a vast fishing zone of some 734 000 km^2 with abundant stocks of tuna, spiny lobsters and pelagics. The Gambia groups its fisheries resources into three main classes; pelagics, demersals and crustaceans (including shellfish).

Mauritania, like Senegal, classifies its resources into two large groups; demersal resources and pelagic resources. The resources have an exploitable potential of about 1 500 000 tonnes per year, of which 65% are pelagic fish, 20% are clams and 15% are demersal fish, tuna and crustaceans (UNEP/CNROP 2002). Regarding pelagic resource, a dozen species out of 50 are exploitable stocks; for example Sardine, Horse mackerel, Mackerel, Anchovy and Mullet. These stock evaluations indicate that tuna, horse mackerel, sardines, and mackerel have the potential to supply 1 million tonnes per year in the EEZ of Mauritania alone.

Status of resources

The various global results available regarding on the coastal demersal resources indicate a serious overexploitation. The signs of overfishing of coastal demersal resources are manifestly evident, declining production of industrial fishing units, exacerbation of the conflicts between artisanal and industrial fishing and even within the artisanal fishery, adoption of new fishing strategies, a significant reduction in mean individual sizes of landed species, and stagnation or reduction in landings per type of fishing in spite of the increasing level of fishing effort. For example, the most recent resource evaluations by Senegal's oceanographic research centre, CRODT, confirm this overexploitation (Barry et al. 2002).

The change in indices of abundance of the species captured by bottom trawls during the CRODT trawl campaigns shows, in all species combined, a significant reduction between the 1970s-1980s and the 1990s. Nearly all fish species are affected by the decrease. The total catches, all species included, declined from about 1 000 kg/hour in 1986 to only 500 kg/hour in 1991 for the entire Senegalese continental shelf, corresponding to a 50% reduction (PNUD/ENDA 2001). The Serranidae group declined from mean abundance level of about 30 kg/hour for all species, already relatively low, to less than 10 kg/hour within the same period (UNEP/ETP 2002). The same phenomenon is observed for the Sparidae group, particularly with regard to the Sparus species, whose relative abundance declined from more than 40 kg/hour to less than 10 kg/hour, and that of guitar-fishes, which changed from 60 kg/hour to 5 kg/hour respectively.

In Mauritania, the level of knowledge on the state of the resources is uneven. The evaluation results for pelagic and cephalopod species, notably the octopus, are considered to be more reliable than those for other stocks, such as the crustaceans and demersal fish. Details of the quality of the results are given in Table 29. The table shows that most of the demersal resources are fully exploited to overexploited. The octopus and the White grouper are overexploited. The hakes and shrimps are fully exploited, as is true for the majority of the big demersal species.

Table 29 Summary of the evaluation of pelagic stocks in Mauritania.

Resources	Current catches (tonnes)	Natural variability [1]	Exploitation	Maximum Sustainable Yield [2] (tonnes)	Excessive effort [3]	Management recommendation
Cephalopods						
Octopus	20 000	Productivity dependent on up-welling and not on exploitation level	Overexploitation, declining indices of abundance.	35 000 (26 000-43 000 according to up-welling)	25-40 %	Reduce fishing effort. Maintain closed season
Cuttlefish [4]	6000	Stable	Probably fully to overexploited	10 000	Unknown	Precautionary approach and encourage selective gears
Squids [4]	4000	Average	Unknown	6 000	Unknown	-
Demersal continental shelf	Emerging statistics: Estimated 40 000-50 000	Average (stock dependent)	Target species fully exploited. Others probably under- to fully exploited	Unknown, probably near current catch.	Probably weak	Freeze effort due to lack of stock evaluation
Black hake	13 000	Unknown	Probably under-exploited. High indices of abundance	12 000	0	Maintain effort at current levels
Mullets [4]	17 000		Big increase in effort	Unknown	Unknown	Freeze effort
Crustaceans						
Deep sea shrimps [4] (*Parapenaeus longirostris, Aristeus varidens*)	3 300/400	High	Probably fully exploited	Unknown	Most likely 0 or weak	Freeze effort (high amount of by-catches)
Coastal shrimps [4] (*Penaeus notialis, P. kerathurus*)	1 900	High	Probably fully exploited	Unknown	Weak	Freeze effort.
Crabs [5] (Gerion)	160	High	Probably fully exploited	400	0	Freeze effort
Red lobsters [5]	200	High	-	800	Unknown	-
Green lobsters [5]	100	High	Northern stock probably recovering	220	Weak	Delay any increase in effort
Clams [5]						
Venus rosalina	0	High	Not exploited	< 300 000	0	-
Venus verrucos	0	High	Not exploited	500-1 000	0	-
Coastal pelagics						
Sardinella	480 000	-	Fully exploited (excepting *S. eba* in Mauritania	500 000	0	Freeze global in the regional-
Horse mackerel	192 000	-	Moderately exploited	400 000	Weak to 0	Maintain effort
Green horse mackerel	21 000	-	No evaluation	Unknown	Weak to 0	-
Mackerel	159 000	-	Moderately exploited	Unknown	Weak to 0	-
Scabbard fish	-	-	-	Unknown	-	-
Sardine	-	-	-	Unknown	-	-
Anchovy	-	-	-	Unknown	-	-
Albacore	135 000 (East Atlantic)	-	Fully exploited	Atlantic stock 144 000	0	Freeze effort and minimum size
Listao	112 000 (East Atlantic)	-	Exploited to fully exploited	Unknown	Weak	None
Patudo	99 000 (East Atlantic)	-	Fully exploited	Atlantic stock 94 000	0	Freeze effort

Note: [1] Natural stock variability independent of exploitation (recruitment variability). [2] Maximum Sustainable Yield (MSY) (This potential cannot be reached without setting the effort to the corresponding level (fMSY), which implies in some cases effort reduction). [3] Current excessive fishing effort to reach the MSY. [4] No evaluation 2002, values and recommendations are from 1998. [5] No evaluation since 1993, 1993 or 1988 values and recommendations.

(Source: IMROP 2002)

Production

Regardless of the species, the total capture production of the countries in the region is well over 1 million tonnes per year. There is a disparity in the individual production by country. According to FAO (2002) statistics the capture production in 2002 was 45 800 tonnes in The Gambia and 895 000 tonnes in Morocco. Senegalese and Mauritanian produced about 79 000 and 376 000 respectively. Cape Verde on the other hand, had a production of 8 000 tonnes.

Contribution to the economy

Due to the particularly productive environment, the sector makes an important contribution to food security, employment and national treasuries of the region. Fish is largely the only source of cheap animal protein. In Senegal and The Gambia, 40% of animal protein is from fish. In spite of the significant quantities exported from the region, the average per capita consumption (about 20 kg per year) of fish is much more than the African average of 8.2 kg per year. The average consumption of fish in the European Union is estimated at 22.1 kg per year and household. The fisheries sector provides direct and indirect employment for some 300 000 people, meaning that about 4% of the active population of the region works in the fisheries sector, engaged in fish harvest, processing and marketing. About 400 local and 300 foreign industrial vessels operate in the region.

The marine fisheries sector is also an important source of revenue for national economies and national treasury revenues, which are often used for servicing local and foreign debts. The contribution of the sector to national economies varies from country to country. Fishing is of vital importance for the Mauritanian economy. It accounted for more than 54% of foreign-exchange inflows and more than 27% of the State budget in 1998 (UNEP/CNROP 2002). The sector's share of GNP is considerable and varied between 5% and 6% between 1984 and 1995 and reached 7% in 1996. The number of jobs created by the various branches in the fisheries sector was probably about 27 000 in 2000, 21 000 of them in non-industrial fishing and about 6 000 in industrial fishing.

In Senegal, earnings from the export of fishery products usually exceeds 160 billion FCFA (approximately 280 million USD), about 20% of earnings from exports (Diouf et al. 2002). With annual fish landings of over 400 000 tonnes (80% caught by artisanal fishermen), the Senegalese marine fisheries provide over 600 000 employment opportunities. In Cape Verde most of the fisheries production is exported to the European Union (EU). The fisheries sector also contributes to national earnings through various bilateral agreements and fishing licence fees. The financial compensation paid to six countries within the region by the EU within the framework of bilateral fishing agreements amounted to 50 million USD between 1992 and 1995 (Saine 1999).

Causal chain analysis

Figure 23 illustrate the causal links for overexploitation of fish in the Canary Current region.

Immediate causes

There has been an increase in both the artisanal and industrial fishing effort in the Canary Current and capacity targeting an apparently

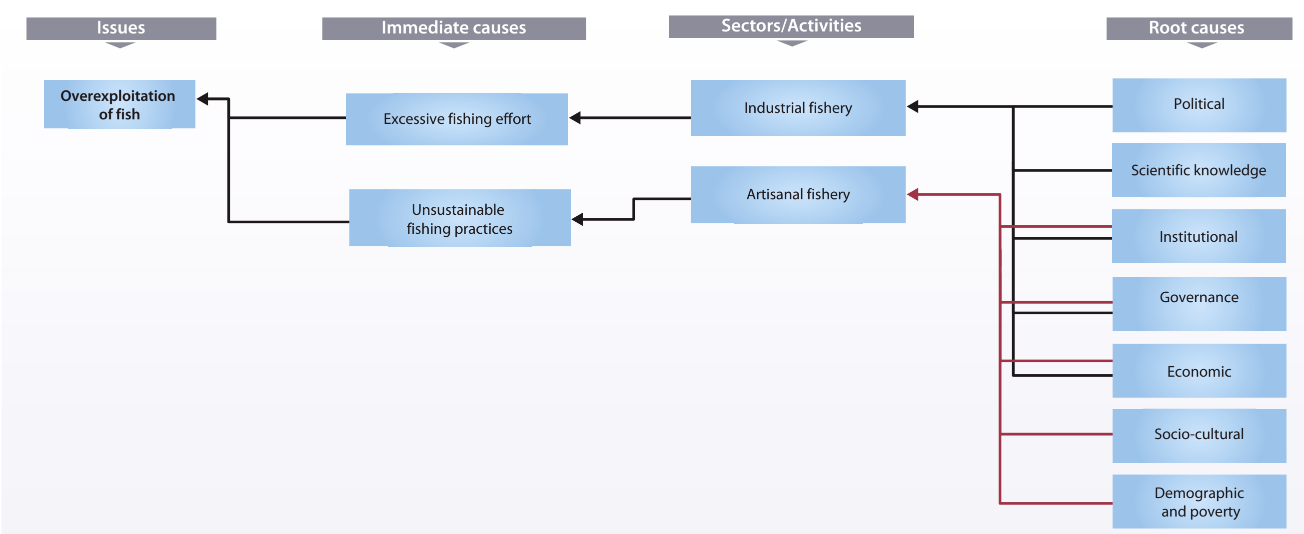

Figure 23 Causal chain diagram illustrating the causal links for overexploitation in the Canary Current region.

declining resource base. An increasing demand for fish and fish products has motivated the use of all means to land more fish by increasing effort and by using destructive and unsustainable fishing methods. The immediate causes of the overexploitation of fish throughout the region are excessive fishing effort and unsutainable fishing practices.

Excessive fishing effort

The sector activities that encourage the increasing excessive fishing effort for coastal demersal resources are essentially the industrial demersal fisheries (various shrimp trawls, red mullet, fish and cephalopods) and the artisanal canoe fisheries (hand lines, hook and line, cages, set nets, etc.).

Industrial fishing effort

As the demand for fish and fish products increases and fish stocks in several parts of the world are depleted, operators have shifted fishing operations to the West African region. This has translated into an increasing number of licensed industrial vessels fishing in these waters, an increase that is not appropriate given the state of the fish stocks. The growth of national industrial fleets was marked by the arrival of more and more powerful and bigger vessels with more powerful engines and medium to high Gross Registered Tonnage (GRT).

In 1994, the Gambian government started implementing its policy of a systematic reduction in the number of licensed industrial vessels. Until 1999, the number of licensed shrimp trawlers remained low (below 40 were licensed yearly) (Figure 24). This was followed by a dramatic and steady increase in 2000. An analysis of catch data from the industrial fisheries in The Gambia also indicates declining annual shrimp (coastal) production and export during the past decade (Figure 25).

Furthermore, due to the acute need for funds for socio-economic development, governments were compelled to grant more fishing licenses to satisfy the demands of countries in the north in exchange for financial and development assistance (Table 30). In Mauritania, the industrial fleet was 69 vessels in 1990 but by 2000, the fleet had grown to about 400 vessels and then about 500 in 2001 (Table 31). These vessels are comprised of Mauritanian vessels as well as vessels from Eastern European countries.

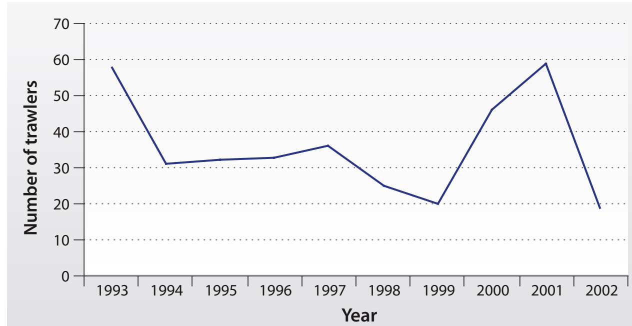

Figure 24 Number of shrimp trawlers fishing in the Gambian waters 1993-2002.
(Source: Gambia Fisheries Department 2002)

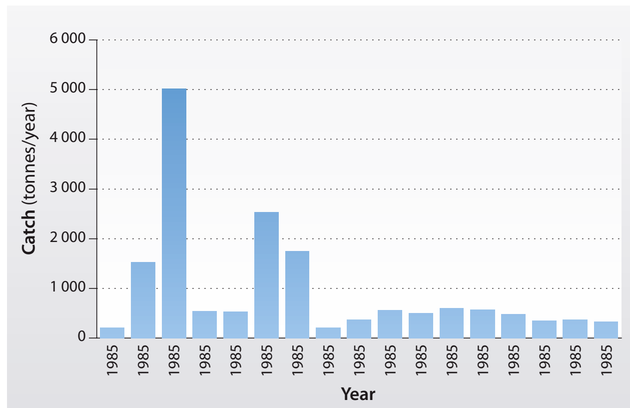

Figure 25 Annual shrimp production in The Gambia.
(Source: Gambia Fisheries Department 2002)

Table 30 Number of licensed industrial vessels operating in The Gambia from 1993-2002.

Vessel	1993		1994		1995		1996		1997		1998		1999		2000		2001		2002
	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun
Stern trawlers	14	22	15	13	5	10	15	10	18	16	15	17	21	42	22	24	14	16	12
Shrimp trawlers	25	33	19	12	13	19	13	20	18	18	9	16	7	13	15	31	22	37	19
Tuna Long-Liners	20	0	12	4	5	15	8	0	5	1	1	4	3	0	2	1	1	0	2
Pair trawlers	0	0	0	0	1	1	2	2	0	0	0	0	0	0	0	0	0	0	0
Tuna Purse Seniors	0	24	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Long Liners	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gill Netters	0	0	0	0	0	0	0	0	3	3	0	7	0	0	0	0	0	0	0
Multiple Purpose /Processing Vessels	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	1	0
Total	61	79	46	46	24	45	38	32	39	40	25	44	31	55	39	56	37	54	33

(Source: Gambia Fisheries Department 2002)

Table 31 Number of vessels authorised to fish in Mauritania 1990-2000.

Type of vessel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Cephalopod vessels	0	113	116	120	134	172	224	239	206	159	160	200
Shrimp vessels	32	25	21	18	22	33	32	41	41	47	42	68
Hake vessels	37	42	37	70	67	71	0	0	0	40	43	40
Demersal vessels	0	0	0	0	0	0	0	0	0	0	0	45
Pelagic vessels	0	59	102	83	53	72	84	61	0	80	83	82
Tuna vessels	0	0	31	34	35	38	34	35	37	65	73	65
Total	69	239	307	325	311	386	374	376	284	391	401	500

(Source: IMROP 2002)

Table 32 Coastal artisanal canoes in The Gambia.

Year	Total number of canoes	Motorised canoes (%)
1980	290	89
1981	490	66
1983	397	66
1986	346	65
1990	472	60
1992	492	76
1994	503	83
1997	494	87
1999	467	95
2000	580	97

(Source: Gambia Fisheries Department 2002)

Artisanal fishing effort

An increase in fishing effort has been observed in the artisanal sector during the past three decades. An increasing number of people have been entering the sector due to declining agricultural production. A 1996 socio-economic survey of The Gambia's artisanal fisheries sector estimated the growth rate of the sector (fishermen and related industries) at about 5% per year (Mendy 1996). Table 32 clearly shows the increasing trend in the number and percentage of motorised canoes operating along the Atlantic coast of The Gambia.

The scenario is similar in other countries of the region. The Senegalese fleet of artisanal canoes is by far the largest in the region. In 2002, the number of the operational fishing units counted along the marine coastline between Djifère and Saint-Louis was about 9 000, compared to only about 100 at the beginning of the 1960s. Some significant modifications have been made to the types of fishing practised by the artisanal demersal fleet. These were mainly the introduction and development of hook and line fishing in 1987 and a considerable increase in the number of canoes with ice holds onboard as well as those fishing with hand line and/or cuttlefish cages. The increase in the use of multiple kinds of fishing gear also became important. In Mauritania, the artisanal fleet consists of 3 000 canoes and 12 000 artisanal fishermen, representing more than three times the number of individuals aboard industrial vessels (IMROP 2002).

Unsustainable fishing practices

Some fishing methods or practices employed by operators in both the industrial and artisanal sub-sectors accentuate overexploitation of the fish stocks. The following non-selective fishing gear and harmful fishing practices/methods are considered destructive and contribute to overfishing:

Beach seining

The beach seine, used by artisanal small-scale fishermen, is destructive fishing gear due to its mesh size, which is smaller than the regulation size. This gear catches juveniles and small-sized fish as well as breeding or spawning adults that are found inshore or along the coast. The adults and other medium-size fishes are retained while the tiny fishes are often discarded or abandoned on the beach. This fishing gear was banned by an act of the Gambian Parliament in 1989, but is used in all countries of the region.

Trawling

This fishing method destroys marine habitats of demersal and benthic organisms as well as the ecosystem. The majority of the licensed industrial fishing vessels in the region are foreign-owned and an increasing number of them are trawlers. Considering the huge number of trawlers fishing in the marine waters of the region under various international agreements, it is easy to see that substantial and often irreparable damage is being done to the nursery, sheltering and feeding grounds, as well as critical habitats of aquatic organisms and the entire ecosystem. Furthermore, the catches of these trawls invariably include a high amount of by-catches comprised of non-target species, juvenile fish, sharks, green turtles and dolphins.

Some studies have found that about two-thirds of shrimp trawler catches are discarded at sea. Out of about 47 321 tonnes landed by Senegalese trawlers in 1998, 2 056 tonnes were discarded at sea (Baddyr & Guenette 1998).

Stow nets (artisanal shrimp fishing)

The negative impacts of this gear, used in the shrimp fishery, are that the mesh sizes do not normally comply with regulations. Smaller mesh sizes are often used, resulting in the catch of small juvenile shrimps and fish. Small shrimp are retained and sold at lower prices while juvenile or small fish are discarded. This constitutes a serious waste of resources and a destructive and unsustainable way of fishing. As there are no closed seasons or restrictions on the fishing zones for shrimps and also no rigorous enforcement of the mesh size regulations, estuarine shrimp fishing by artisanal small-scale fishermen has become a destructive fishing activity.

Shark fishing

The development of a distinctive artisanal shark fishery started towards the end of the 1960s, pioneered by an immigrant Ghanaian fishing community that had developed specialised skills in the catching, processing and exporting of dried, salted shark meat from their base in The Gambia (Saine 2000). These Ghanaian shark fishermen now operate in coastal countries throughout the region from Mauritania to Guinea. In the early 1970s a lucrative shark fin market emerged in Southeast Asia. Prior to these dates, there was no direct intense targeting of sharks by the artisanal fishery. By-catches were simply processed, marketed and consumed.

The shark fishing industry has become a lucrative business because of the attractive prices being paid for shark fins in Southeast Asia. In a bid to land more shark fins, artisanal fishermen have cut off the fins of the animals and the living animals are thrown back into the water. A new twist in the shark fishing techniques is the use of dolphin meat as bait (Anane 2001).

Scientists at Ghana's Centre for Industrial and Scientific Research have concluded that shark fishing contributes to the reduction of dolphin populations in Ghanaian waters due to the use of dolphin meat as bait for catching sharks. This practice by Ghanaian fishermen, leaders of the shark fishery throughout the West African region, is a danger to dolphins, which are already protected as threatened species in several West African states.

Poaching

Fisheries regulations in all countries of the region have reserved the inshore and offshore parts of their fisheries waters for artisanal small-scale fisheries operators. Licensed industrial fishing vessels are compelled to fish outside and beyond this reserved zone. However, industrial fishing trawlers often fish in this area, thereby destroying the nursery and feeding grounds of juvenile fish, damaging the fishing nets and other gear of artisanal fishermen and causing conflict. Table 33 shows records of the activity of unlicensed/delinquent vessels in The Gambia in 2000 and 2001.

Table 33 Unlicensed/delinquent vessels in The Gambia.

Year	Number of vessels spotted	Number of violating regulations	Violating regulations (%)	Number of arrested
2000	816	85	10	7
2001	103	8	8	5

(Source: Jones pers. comm.)

With increasing effort and declining fish resources, artisanal fishermen are also motivated to go further out to sea in search of fish, thus going beyond the area reserved for them and entering the industrial fishing zone where they come into conflict with industrial fishing trawlers. Despite the regulations delimiting fishing zones and all the effort being made to monitor and control industrial fishing, several vessels annually are caught poaching (fishing without license) or fishing in the wrong zone or using unauthorised/illegal fishing gear. The Sub-Regional Marine Fishing Surveillance Project (AFR/013) of the Sub-Regional Fisheries Commission (SRFC) based in Banjul reported that between 2000 and 2001, only 12 out of a total of 93 vessels were arrested after being spotted by the Project's aerial surveillance aircraft while violating fisheries regulations (Lux-Development/FAO/SRFC 1999).

Use of explosives

With diminishing fish stocks, artisanal fishermen in some countries in the region such as Senegal and Mauritania, have resorted to using explosives in fishing. It has been unanimously acknowledged that the use of dynamite destroys the rocky zones that are essential breeding grounds for several important species.

Root causes

The root causes of overexploitation of fish have been analysed for industrial and artisanal fisheries. Root causes are categorised under these two themes as described below.

Excessive fishing efforts - Industrial fisheries

Economic

Beginning in the 1970s most governments in the region implemented policies aimed at development of the industrial sub-sector by providing assistance for the construction of fishing vessels. These policies provided industrial gear and semi-industrial vessels to the artisanal fisheries and resulted in the introduction of new types of coastal demersal fishing. All these interventions invariably resulted in overcapitalisation.

In the early 1980s, government support was oriented toward facilitating the development of fisheries products for exports. This support included the provision of duty-free concessions and incentives such as exemptions from various duties (subsidy on export, 25% for value-added industrial products) and taxes (Deme 1999). The Lome Convention facility, which granted a duty and tax exemption for fisheries products entering Europe from ACP countries, along with fishing agreements contributed to the increasing link of the sector to external markets for countries in the region.

The objective of all this fiscal support was to facilitate the establishment of fish-processing enterprises to take advantage of the growth in world demand for fisheries products, notably in developed countries. This was expected to reduce the balance of trade deficit through the acquisition of foreign exchange. The activities of these numerous enterprises have exacerbated the demand for exportable products, resulting in the intensification of the fishing effort and seriously threatening demersal stocks.

Institutional

Countries of the region have signed fishing access agreements with foreign countries and interest groups, by far most the important of which are those with the European Union that target already highly threatened species. Presently, all the countries in the region bordering the Atlantic Ocean, excepting The Gambia, have an ongoing fishing agreement with the European Union. These agreements were entered into primarily because the stocks were believed to be abundant enough to satisfy the requirements of citizens of the countries in the region and also because the countries did not have the capacity to exploit their fish stocks.

The fishing agreements are viewed by several experts as one of the main causes of overexploitation of the marine resources in African countries. By lowering the production costs of fishing units, the agreements encourage them to fish beyond the economic optimum compatible with sustainable use of the resources. Furthermore, since the agreements involve specific, allocated industrial fishing, the vessels would not hesitate to reject non-target species or small individuals, in order to maximise the value of their catches. On the other hand, this fishing activity by foreign fishing fleets is not being properly monitored due to the lack of adequate surveillance resources.

Now that the national fleets are able to exploit these stocks, and do so fully, there is no reserve left over that could justifiably be sold to any foreign fleet. The real reason for these agreements could be assigned to the huge financial compensation offered by the European Community to the signatory coastal countries.

Scientific knowledge

The management of the stocks is largely based on scientific knowledge related to biological, economic, sociological and technological factors. The limited scientific knowledge concerning some of the stocks constrains the participants from using optimal strategies and tactics and establishing plans for responsible use necessary for the sustainable development of the fisheries sector.

Governance

Management of the fisheries sector in virtually all countries of the region is characterised by an inefficient system of the monitoring, control and surveillance. The inadequacies in the monitoring, control, and surveillance systems are blamed for the frequent incursions by industrial vessels into the coastal zone reserved for artisanal fishing (spawning grounds), the use of unauthorised fishing gear, destruction of the resources and the marine environment, frequent illegal fishing (poaching) by unlicensed industrial vessels and the fraudulent shipment of catches at sea to the detriment of local markets and industries.

The regulations are, in some cases, inappropriate and difficult to implement. Both fisheries regulations and legislation are characterised by a command and control approach, which is further limited by a lack of education, information and communication. National and local advisory bodies do not have sufficient power to make decisions. All these practices constitute a serious threat to the sustainability of the fisheries and to the maintenance of biodiversity. They encourage the overexploitation of resources, particularly coastal demersals.

Political

For strategic and empowerment purposes, and to enhance their negotiating capabilities, operators in the industrial fisheries sub-sectors have formed different Socio-Professional Organisations (SPO) such as the Association of Vessel Owners and Industrial Marine Fisheries (GAIPES), the Union of Fishermen and Export Traders in Senegal (UPAMES) and the Association of Industrial Fishing Companies in the Gambia. These SPOs, at the political level, are powerful lobbies that protect the interests of their profession members. These interests are not always in the best interests of sustainable development and use of the fisheries resources.

Excessive fishing effort - Artisanal canoe fisheries

Demographic

At the current growth rate of around 2%, the population of the region, will increase by two-fold practically every 25 years. This population explosion is linked to a high urbanisation rate essentially due to rural migration. The urban population could soon exceed 60%. There will be a net increase in the demand for fisheries products by the local market as well as for export. If the 22 kg consumption per capita estimated for the urban area is maintained, the demand for fisheries products would be 1 million tonnes in 2012. To maintain the same level of export, the production of about 2.1 million tonnes would be necessary.

Poverty and lack of awareness

The poverty rate in the coastal zones of the region is particularly high and there is a great dependence on coastal resources, particularly fish, for income generation and food security. Generally, resource users, the coastal communities and other stakeholders lack awareness about the state of the resources and the effects of overexploitation on its sustainability.

Although it is evident that some of the resource users are aware of the problems with regard to the general state of the resources, poverty and the absence of alternative sources of livelihoods compel them to persist in these unsustainable resource use practices. Most of the resource users and other stakeholders have known nothing aside from fishing and fishing-related activities for their livelihoods. The changing trends in society and cultural values have little positive effects on how they view these resources, along with ownership and access. Generally, these resources are considered common property and open-access resources.

Economic

Initially, the state intervened in favour of production by the artisanal sector, and in this connection motorisation of canoes was facilitated. Outboard engines became the trend in the artisanal fisheries sub-sector. Motorisation was accompanied by several supporting provisions, such as duty waivers, fuel subsidies, and the creation of financial institutions to fund the sector. The objective was to reduce production (exploitation) costs of the artisanal fishing units to enable them supply the local market with prices commensurate with the incomes of the local population.

The fuel subsidy for artisanal canoes was a determining factor in the modernisation of fishing equipment. It enabled fishermen to use more powerful outboard engines and bigger canoes, and to stay longer at sea, which allowed access to new fishing grounds. There is no doubt that the fuel subsidy had an important impact on the increase in the time spent at sea by hand-line canoes equipped with iceboxes. This contributed to the intensification of fishing effort for demersal fisheries. Maintaining the subsidy under current conditions, where the profitability of fishing units targeting the export market has improved, is no longer justifiable.

These efforts by the countries involved have enabled the sub-sector to be modernised and integrated into the world market. Far from confining itself to simply supplying the local market, new types of artisanal fishing have been developed for export markets (cage fishing, for example). This redeployment of artisanal fishing effort to supply the international market, stimulated by the present administrative set-up, contributed largely to the current state of demersal resources overexploitation. Because the artisanal sub-sector provides raw material (more than 60% in Senegal) for factories, these indirect subsidies also benefit the export operators to the same if not greater extent than local populations.

Overexploitation of demersal resources is likely to worsen, especially since the possibility of reconverting artisanal fishers is limited.

Institutional

There are no fees or requirements that govern entry into artisanal fishing or access to the resource. This free and open access to the resource partly explains the industry's spectacular growth. For example, in Senegal, the artisanal canoe fleet grew from a few hundred units in the 1960s to close to 15 000 canoes today. This sub-sector accounts for more than two-thirds of fisheries production, yet operates without any control on its fishing effort. The free and open access to the fisheries resource has enabled industrial fishers without fishing licenses to have access to the resource by collaborating with or sponsoring artisanal units. Close to 95% of the Senegalese canoe fleet targets coastal demersal species.

Socio-cultural

Generally, the artisanal fishing profession is handed down from father to son. With the particularly high demographic growth rate in fisheries communities, the opportunities for reconversion are very limited and with the economic crisis affecting most countries in the region, the number of artisanal fisheries operators is bound to increase exponentially. As resources are not unlimited, there is the possibility of a biological disruption of several demersal species if the present tendencies are not reversed.

Governance

The artisanal fisheries in the region operate with several different types of gear and target different species at the same time. They operate on a long coastline (Mauritania 745 km and Senegal 531 km) and land on countless fish landing sites (more than 200 in Senegal, about 50 in The Gambia). Confronted with scarce resources in waters under Senegalese jurisdiction, the artisanal fishermen are now found in several coastal countries of the region (The Gambia, Mauritania, Guinea-Bissau). Additionally, as a way to fish all year round, artisanal fishermen have adopted the use of a combination of several types of gear. Because it is a very complex sub-sector, artisanal fishing is faces acute governance problems in its management. The situation is made more difficult by very limited logistical and human resources for the administration of the fisheries.

Political

In all of the countries in the region, recognised Socio-Professional Organisations (SPO) bring together actors in the artisanal fisheries sub-sector. Actors in all areas of activity are involved; fishing, marketing, and artisanal processing of fish products. In Senegal, these organisations have created a federation to better defend their interests. This big lobby of artisanal fishermen through their influential SPO is blocking the institution of an artisanal fishing license system.

Unsustainable fishing practices - Industrial fishing

Economic

A factor accelerating the reduction in species abundance is the discards at sea by industrial freezer trawlers, which retain individuals of acceptable size while rejecting small juvenile fish caught by their nets. These discards, which constitute a waste of precious diminishing resources, pose socio-economic risks as they affect the catch of other fisheries that target these rejected species. Discards also have a significant impact on the equilibrium that exists among the different exploited stocks.

Institutional

Unsustainable fishing practices by the industrial fisheries sector can be attributed to a lack of compliance with fisheries regulations. The presence of observers aboard licensed industrial fishing vessels operating within the framework of fishing agreements ensures compliance with the regulations governing their activities. This is not the case with all Senegalese registered vessels. National vessels commit the majority of recorded infringements, or incursions into reserved zones, mesh-size violations, and the use of unauthorised gear by licensed vessels.

Unsustainable fishing practices - Artisanal fishing

Economic

By offering attractive prices for certain desirable species, hotels encourage the fishing of immature species (small White groupers, young Pink sea breams, lobsters and small-sized locust lobsters). An increase in these activities has been reported as related to tourism in the region. In Senegal, the large demand from fish feed meal factories in Dakar and traders from countries in the Gulf of Guinea also encourage the landing of juvenile fish.

Socio-cultural

Beach seines with nets more than 1 000 m in length represent the gear used by a great percentage of the canoe fleet. Ownership profiles show that these units are in general village-based. Although beach seines play a vital role in production and socio-economic development, they mostly capture juvenile fish and thus seriously threaten the sustainability of the fishery.

Institutional

A lack of enforcement of regulations has enabled certain artisanal operators to resort to illegal fishing techniques (fishing with explosives in Senegal and Mauritania) and gear (mono-filament, nylon nets in almost all states of the region). Such practices are largely responsible for the destruction of marine fauna and flora. It has been unanimously acknowledged that the use of dynamite destroys the rocky zones that are essential breeding grounds for several important species. These nylon nets are non-biodegradable and therefore remain in the sea. A lack of enforcement of the mesh size regulations and the allowed minimal sizes and weights for fish to be landed also exacerbates overexploitation of the resource.