Assessment

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 8.

Table 8 Scoring tables for the Canary Current region.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter).
0 No known impact
1 Slight impact
2 Moderate impact
3 Severe impact

The arrow indicates the likely direction of future changes.
↗ Increased impact
→ No changes
↘ Decreased impact

Canary Current North	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	1.5* ↗	2.0 ↗	0.8 ↗	1.0 ↗	**1.9**	**1**
Modification of stream flow	1					
Pollution of existing supplies	1					
Changes in the water table	2					
Pollution	1.0* ↗	1.0 →	1.0 →	1.0 →	**1.1**	**3**
Microbiological pollution	0					
Eutrophication	1					
Chemical	1					
Suspended solids	2					
Solid waste	1					
Thermal	0					
Radionuclides	0					
Spills	1					
Habitat and community modification	2.0* ↘	1.6 ↘	0 →	0 →	**0.7**	**5**
Loss of ecosystems	3					
Modification of ecosystems	1					
Unsustainable exploitation of fish	2.3* ↘	2.0 ↘	0 ↗	1.6 ↘	**1.4**	**2**
Overexploitation	3					
Excessive by-catch and discards	2					
Destructive fishing practices	2					
Decreased viability of stock	0					
Impact on biological and genetic diversity	2					
Global change	0.8* ↗	1.0 ↗	0 ↗	1.0 →	**1.1**	**4**
Changes in hydrological cycle	1					
Sea level change	1					
Increased UV-B radiation	0					
Changes in ocean CO_2 source/sink function	0					

Canary Current South	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	1.8* ↗	2.0 ↗	2.2 ↗	1.4 ↗	**2.3**	**1**
Modification of stream flow	2					
Pollution of existing supplies	2					
Changes in the water table	1					
Pollution	1.8* ↗	1.0 ↗	1.0 ↗	1.8 ↗	**2.0**	**4**
Microbiological pollution	1					
Eutrophication	2					
Chemical	2					
Suspended solids	2					
Solid waste	2					
Thermal	0					
Radionuclides	0					
Spills	1					
Habitat and community modification	3.0* ↘	2.6 ↘	1.8 ↘	1.0 →	**1.8**	**3**
Loss of ecosystems	3					
Modification of ecosystems	3					
Unsustainable exploitation of fish	2.5* ↘	2.5 ↘	1.2 →	2.4 ↘	**1.8**	**2**
Overexploitation	3					
Excessive by-catch and discards	2					
Destructive fishing practices	3					
Decreased viability of stock	0					
Impact on biological and genetic diversity	2					
Global change	0.8* ↗	1.0 ↗	1.0 ↗	1.0 ↗	**1.5**	**5**
Changes in hydrological cycle	1					
Sea level change	1					
Increased UV-B radiation	0					
Changes in ocean CO_2 source/sink function	0					

* This value represents an average weighted score of the environmental issues associated to the concern.

** This value represents the overall score including environmental, socio-economic and likely future impacts.

*** Priority refers to the ranking of GIWA concerns.

It should be noted that the present assessment is based upon available data. A number of data gaps and an imbalance in the availability of data exist, which makes the assessment speculative in some cases. To adequately address the concerns and issues, empirical evidence from research elsewhere was used and applied to the regional context.

Freshwater shortage

Canary Current North **Canary Current South**

The region has limited mineral resources and has generally attained low to medium levels of industrialisation. Hence, the region's river basins contribute significantly to both rural and urban development. Rivers are exploited for crop and livestock development, rural and urban domestic water needs and industrial development.

A large portion of the region is located in the Sahel region, meaning that surface water is limited to areas with significantly high levels of rainfall. This effectively controls the characteristics of the rivers in the region. Within this context, the uneven distribution of surface waters is quite notable in the region. Mauritania and Mali are characteristically dry countries while substantial parts of Senegal, The Gambia, Guinea and Guinea-Bissau are characterised by ample amounts of annual rainfall. With these characteristics, overextraction of large amounts of water by upstream nations automatically jeopardises the availability of the resource for downstream users. Overextraction also leads to changes in biodiversity.

The primary concern of this assessment is focused on rivers of transboundary nature; the Senegal and Gambia rivers for the Canary Current South and the Souss-Massa and Sebou rivers for the Canary Current North sub-system.

Environmental impacts

Modification of stream flow

Stream or river flow may be altered by natural causes and this is discussed under the Global change concern. However, stream flow modification, particularly in the Canary Current South sub-system, has been caused primarily through damming of rivers that in turn has resulted in changes in flow regimes, losses of flood plains, losses or degradation of wetlands and increased erosion of riverbanks. Many seasonal rivers and streams drain this sub-system and provide support to food production. These seasonal rivers run for a very limited period and their economic impacts are therefore very limited.

Box 1 Impacts of stream reduction in the Souss-Massa Basin.

In the northern part of the Canary region, the Moroccan government has built several dams along the Souss River. Hundreds of small, seasonal springs flow down from the Anti-Atlas Mountains into the Souss. While the construction of dams supports industrial agriculture (citrus and tomato exports) in the region, it has disturbed the ecological equilibrium of Souss-Massa's Natural Reserve. Since less water is able to reach its wetlands, the size of the reserve has decreased dramatically. This lack of free-flowing water affects wildlife in the region. Fewer migratory birds, for example, linger at the reserve, and fewer still select it as their final destination. For the most part modernisation has improved water quality. Wells are all lined and most have a bib or a concrete border on the ground around the well to prevent seepage of contaminants into the wells. Technology has also made it possible to treat wells with bleach and iodine. In some villages more modern methods have made it easier to retrieve water such as a tap system, or electric pump that eliminates the need to use a pulley system. An even more modern washer/wheel method has made drawing water from wells less laborious. However, these modern techniques have not reached Tagmoute and the washer/wheel pump cannot be used to make drawing water easier in Tagmoute because the wells are too deep. So as of 1999, villagers rely on old pulley systems that are quite laborious. The introduction of plastic has made for some lighter water containers that are more hygienic. Unfortunately the increase in garbage caused by packaging and the lack of a suitable garbage site has led villagers to discard trash in the dried up riverbed. Garbage is also found throughout the oasis, which will obviously harm the local vegetation and animals. The water situation is greatly improved by the presence of wells and a piping system that delivers drinkable water to every home. This saves women in the village endless hours when they do not have to spend gathering water from the well. Aside from the saltwater that enters wells due to the ocean's proximity, the problem is drought. In 2002, Morocco's dams were filled to 75% of their capacity. Water shortage is a problem that is mounting with increasing desertification, deforestation, and population growth. Farmers are highly cognisant of the water shortage, as some of their fields depend on rainfall for water. The fields closer to the River have irrigation to help them, but these, too, are affected when the water level drops in the River.

(Source: Powell et al. 2003)

Fundamentally, the hydrological regime of the Senegal, Gambia, Souss and Sebou rivers has been subjected to considerable changes in annual discharge and surface area during the past four decades. While drastic changes in the region's river and stream discharges have occurred due to natural factors (climate change), a significant proportion of the changes are due to dynamic human activities. Increasing demographic characteristics and urban and industrial growth are among the factors that have contributed to the changing landscape and thereby, to modified stream flow (See Box 1).

The regime flow of Senegal River in particular has been significantly modified by the construction in 1987 of the Manantali Dam, which is located upstream in Mali. Similarly, the construction in 1997 of the Diama Dam downstream in Senegal near the river mouth has contributed to coastal erosion. Construction of the Diama Dam helped curb the back flow of saline water (JICA 1999). Small dams on the Gambia River (Kekret and Kouya Dams) have similar impacts on their respective river regimes (Diagana 1994).

The most common impact of damming includes inundation of large areas, siltation, salinisation and other consequences from infrastructure construction, such as, roads, building, and vegetation removal. It is reported that construction of the Manantali Dam changed the pattern of flooding, resulting in severe problems for the agro-pastoral communities (Diagana 1994).

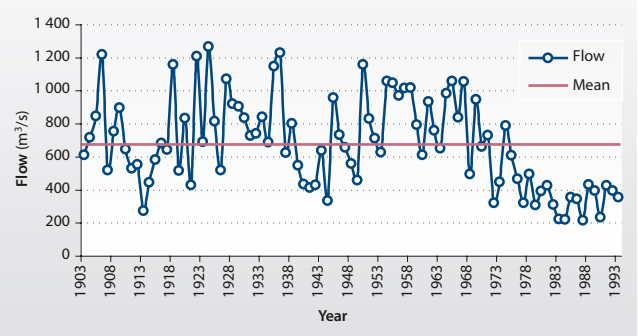

Figure 8 Senegal River discharge variation at Bakel, 1903-1994.
(Source: Diagana 1994)

A standardised time series study of the annual discharge of the Senegal River shows that the River has had a period of significant deficit after 1970 (Figure 8). The percentage of reduction between the mean annual discharge over the years before 1970 and the deficient periods is over 40% (Diagana 1994).

Human activities such as damming, urbanisation, agro-industrial development and settlements along major rivers in the region have caused erosion in coastal areas (Box 2). Deforestation, particularly of native forests, has been very significant in the Senegal Basin. According to the World Resource Institute (WRI 2003) all the indigenous forests along the River have been exploited. Exploitation of exotic forest species is estimated to be about 5% per year. Nevertheless, 6% of the drainage area is designated as protected. Wetlands occupy approximately 4% of the drainage area, some of which are rated among wetlands of international importance under the Ramsar Convention (Vincke & Thiaw 1995). In the Senegal River, the sediment load is as high as 1.18 to 2.86 million tonnes per year, which has threatened lagoon-based cities near the river mouth (Arthurton et al. 2002).

Pollution of existing supplies

For the Canary Current South sub-system, the African Environment Outlook (UNEP 2002) has reported "rising levels of pollution of surface and groundwater resources." Pollution of existing water supplies is attributed to sewage and industrial effluents, agricultural run-off, sedimentation due to poor farming techniques, sand storms (wind erosion), and coastal erosion (JICA 1999).

In Morocco, some rivers and aquifers in contact with saliferous terrains contain as much salt as 320 g/l. In the Tadla area in Morocco, the main river has its source in a saliferous zone and carries 3 g/l during the period of minimum flow. It is estimated that more than 130 000 km^2 of land in Morocco have no outlet to the sea. In these hydrologically closed systems, water is not renewed and the concentration of salts has increased over time. An example of this situation is the in Gharb region (in the Sebou River) where incoming surface waters are of good quality (electrical conductivity of about 1 mmhos/cm) but groundwater frequently contains more than 10 g/l of dissolved salts, especially when water table is shallow (Tayaa & Bazza 1994). Salinisation has also been enhanced through anthropogenic activities such as inadequate irrigation with saline waters and floodwaters. The spreading of flood

Box 2 Transboundary problems resulting from the Diama and Manantali Dams on the Senegal River.

The Diama and Manantali dams were constructed on the Senegal River in 1985 and 1988 respectively. Each of the dams was built for a specific purpose, the Diama was built downstream of the Senegal (around 30 km upstream from the river mouth) for the purpose of preventing saltwater intrusion. It is closed during the dry season from November to June, and is gradually opened during the rainy season, generally around July. The Manantali Dam was built 1 200 km upstream from the river mouth on one of the main tributaries of the Senegal River for hydroelectric power purposes. The main goal of this construction was to provide water for irrigation along the Senegal River valley and a freshwater supply for Lake Guiers, which itself is a water supply for Dakar, the capital of Senegal. The environmental impacts of the dams are:

- Water quality modification, particularly in the delta region, with increased water-borne parasitic diseases (specifically, increased intestinal bilharzia, which had never been observed before the construction of the dam, in the region of Richard Toll, 60 km upstream of Diama Dam). A field survey between 1988 and 1989 of 1 000 randomly selected individuals of all ages showed a prevalence rate of 60% for intestinal bilharzia (Talla 1992). Furthermore, it is reported that dissolved oxygen levels have markedly decreased, with an associated accumulation of nitrate and nitrite (Bâ 1992).
- Reduction of fish yields downstream of the Diama Dam.
- Inundation of certain localities near the main city, Saint Louis, downstream of the dam during particularly rainy seasons.

Detailed studies between 1989 and 1992 (Michel et al. 1993) have shown that, after the construction of the Diama Dam, complex and unstable coastal systems, such as the Senegal River Delta, have undergone profound changes. While the Senegal river mouth is located on a sandy coast with a weak tide, the equilibrium (erosion and sedimentation) of the coastline (the "Langue de Barbarie" sand spit, in particular) and the inner part of the river mouth are both highly dependent on the longshore drift and the transported sand. Therefore, the construction and operation of the Diama Dam greatly affects the river mouth and coastal geomorphology during both the dry and rainy seasons. For example, between 1986 (when the Diama Dam began to function) and 1994, the Senegal River mouth moved southwards more than 3 500 m, and is now located to the extreme south of its former location. Furthermore, a higher sedimentation rate on the marine side as compared to the riverside contributed to reinforcement of the marine side of the "Langue de Barbarie". The Senegal River mouth will certainly be maintained for a while at the southern part of the Delta. Field measurements (including topo-bathymetry transects and sedimentological analysis), spot imagery processing and recent topographical map comparisons have allowed a better understanding of the functioning and evolution of the Senegal River Delta.

Construction of the Diama and Manantali Dams created an additional 240 000 ha of land for irrigation on the Senegalese side of the Senegal River, giving the country the opportunity to diversify its crop base and increase food production, but this was achieved at a cost. The two dams also created controversy by altering the hydrological regime of the River, thus generating transboundary problems. Upon completion of the dams, farmers and fishermen living downstream were exposed to increased health problems from water-borne diseases such as malaria and schistosomiasis. Operation of the upstream dam also reduced annual floods along the floodplain, where an ancient and productive form of recessional irrigation had been practiced for hundreds of years. Recessional irrigation is still practiced along these flood plains on an estimated 50 000 ha, but floodwaters from the Manantali Dam do not carry the same load of nutrient-rich silts which are deposited on the fields after the flood waters retreat.

(Source: Diop et al. 2000)

waters leach some of the salts present in the soil at the time of application but cause actual evaporation to increase and new salts are brought up to the soil surface. Water quality is a problem in some peri-urban areas along the coast, where wastewater has exacerbated problems (CSE 1988).

In Yeumbeul, Senegal, 7 000 households are dependant on groundwater sources that are contaminated by high levels of nitrates over and above the WHO recommendations of 50 mg/l (UNEP 2002). In Dakar, most of the industries discharge raw industrial waste into water-bodies, due to lack of treatment plants. Furthermore, tourist facilities such as hotels also discharge pollutants in water-bodies. Another pollutant source is intensive agriculture, which consumes a great quantity of fertilisers. The Senegal River and Lake Guiers are examples of water bodies polluted by fertilisers. In recent years, the Great Dakar region has experienced chronic water deficits of potable water (JICA 1999). As an example, aquifer waters taken from wells around Dakar showed very high concentration of sodium, potassium, calcium, magnesium, sulfates, nitrates, bicarbonates and chlorides (JICA 1999). The highest bicarbonate concentrations were recorded along the sea front (3.41 mg/l) and an area of unconfined aquifer the least influenced by human settlement (1.32 mg/l). In terms of nitrate, 20 mg/l was recorded in the eastern sector of the peri-urban area, which is less impacted by human settlement. However, excessive concentrations above 200 mg/l were recorded in the peri-urban district of Dakar, which is without sanitation system and is characterised by a predominance of slums. In addition, Niang-Diop et al. (2002) noted that approximately 660 000 ha in Senegal has been affected by salinisation, with 260 000 ha of this area along the coast, and the remaining 400 000 ha found in the Casamance Basin, near the Senegal river mouth.

In summary, pollution of groundwater in the region exacerbates freshwater shortages. Nevertheless, countries from the region in general have experienced considerable improvement in to safe drinking water (WHO standards), particularly for urban populations (Table 9).

Table 9 Access to safe drinking water sources in urban and rural areas in the region.

Country	Access safe drinking water	
	Urban areas (%)	Rural areas (%)
Senegal	90	65
Mali	75	60
The Gambia	95	77
Guinea-Bissau	79	49
Morocco	99	57
Mauritania	33	40

(Source: WHO 2001)

Changes in the water table

The coastal areas of Morocco, Mauritania and Senegal have substantial groundwater aquifers (Senegal-Mauritanian Basin, Taoudeni Basin, Souss-Massa Basin and Errachidia Basin) (ONEM 2001). Major constraints on the use of groundwater arise from the lack of precise data about aquifers, such as capacity, depth and contamination. However, the GIWA Task team recognised that over the past three decades, there has emerged clear evidence of declining base flow in most of groundwater systems in the region. This rapid decline is due to increasing population pressure and the diversification of economic activities. This scenario makes groundwater exploitation very likely in the years to come. Data availability for aquifers in the region is, however, quite limited.

In the Canary Current North sub-system, data from Morocco show that in the Souss-Massa Basin irrigated perimeter, the aquifer drawdown can be as high as 2 m per year and has ranged between 10 to 65 m since 1970 (CSEC 2001). Because of decades of drought, recharge rates are very low and there are problems with overabstraction.

In the Canary Current South sub-system, the decline has been linked to the long dry periods (more than 30 years) and overextraction of groundwater for irrigation (Diene 1995). In Pout and Sébikhotane in Senegal, the aquifer drawdown is 1.5 m per year. There are substantial groundwater aquifers, but because of low precipitation, recharge rates are very low and there are problems with overextraction, especially near Dakar (AWRMI 2001).

Socio-economic impacts

Agriculture, fisheries, industry and tourism are the socio-economic activities most affected by these water problems. The majority of the countries in the region rely heavily on the agricultural sector for food security, raw materials for industrial development and export earnings. Therefore any impact on the productivity of this sector depresses the entire economy of countries involved. However, it should be recognised that the construction of dams on the Senegal and Gambia rivers have also contributed to hydropower generation and irrigated farming.

The inland fisheries is equally important in terms of food security and income generation. The Canary Current South sub-system countries rely on fisheries from the Senegal and Gambia rivers. High fish catches are achieved during high river peak seasons and is lowest with increased catch effort during low flow periods. Therefore, the increasing fluctuation in the river regime, particularly as a result of diversions

and climate change, has negative impacts on the fishing sector and in essence contributes to indirect costs in time spent on the activity. ACOPS (2001), reported losses of up to 50 000 tonnes (1972) and 30 000 tonnes (1990) of estuarine fisheries in the rivers due to stream flow modification. Inland fisheries provide regular employment for millions of poor people, and seasonal or part-time employment for many more. This work is closely linked to other activities such as farming, livestock rearing, and fuel wood collection. It has been reported that salt intrusion along the coastal areas of Senegal was partly the reason for the abandonment of the Katakalouss shrimp culture project (Bousso et al. 1993).

Economic impacts of freshwater shortage are also reflected in the high costs associated with the construction of dams and inter-basin transfer schemes to supply water. The Senegal River has a number of large-scale dams, as mentioned above. Morocco has also developed intensive and extensive water resources networks that involve high investment and maintenance costs. Landlocked Mali has a severe shortage of freshwater and has been highly dependent on donor funding to pay for alternative water sources in recent years. Additional economic impacts associated with freshwater shortages are the increased costs from pumping groundwater that results from the need to drill deeper wells. A significant percentage of the population of the Cape Verde Islands depends on groundwater for domestic use, and the increasing costs make this dependency extremely expensive. The same situation applies to Morocco, which relies on groundwater for irrigation development. The majority of the countries in the region are dependant on hydroelectric power for their energy supply, which in turn is directly affected by changes in the water regime. This impact is also reflected in the costs of desertification, and increased effort required for searching for alternative water resources.

Health impacts were assessed slight and moderate in the Canary Current North annd South sub-systems respectively. Polluted water supplies are source for microorganisms that can cause water-borne diseases. Reservoirs associated with dams provide a hospitable environment for carriers of water-borne diseases such as bilharzias and guinea worm, which leads to river blindness (Box 3). Against this backdrop, health impacts were ranked based on the effect of these water borne diseases, particularly diarrhoea, cholera and bilharzia and guinea worm, which constitutes a major health problem mainly in Mali, Senegal, Guinea, Guinea-Bissau, Mali, and Niger. Onchocerciasis (river blindness), the world's second leading infectious cause of blindness, is found in 36 African countries. As a public health problem the disease is most closely associated with Africa, where it constitutes a serious obstacle to socio-economic development. A black fly that abounds in fertile riverside areas is the vector that causes the disease.

Box 3 Health impacts due to stream flow modification: Damming of the Senegal River Basin.

Water reservoirs combined with channeling of water for irrigation have created debilitating health problems for the people living in the Senegal River Basin. The permanent presence of standing water in the valley has led to a continuing increase of water-borne diseases that were already common in the area: malaria, diarrhoea, intestinal parasitic diseases, and particularly bilharzias, for which the Senegal valley unfortunately holds the world record (Verhoef 1996). Intestinal bilharzia had never been observed in the Canary Current South sub-system before the construction of the dam 60 km upstream of Diama Dam. A field survey between 1988 and 1989 of 1 000 randomly chosen subjects of all ages showed a prevalence rate of 60% for intestinal bilharzia (Talla 1992). Cholera outbreaks, which typically used to occur only during the rainy season, appear to have become quasi-endemic. The increase in schistosomiasis has resulted from the creation of freshwater bodies, such as irrigation canals and ponds, where disease-bearing snails that were previously controlled by seasonal fluctuations and salt inflows are now able to breed. The mortality rate caused by water-related disease as calculated in 1997 was 8 000 per year. It was estimated that measures to manage flows from the dams could reduce the annual number of deaths by 2 500.

(Source: Finger & Teodoru 2003)

These fertile riparian areas frequently remain uninhabited for fear of infection. Out of some 120 million people worldwide that are at risk of onchocerciasis, 96% are in Africa, and majority of these are in the countries of the Canary Current South sub-system (Tandia & Dieng 2001). In addition, previous surveys have shown that groundwater pumped specifically for drinking in suburban areas is contaminated with the parasites and bacteria that lead to diarrhoea, particularly in children.

Health impacts are relatively small in the Canary Current North sub-system, based on the size of affected population in comparison to the population as a whole. However, in Morocco, water-borne diseases caused by changes in the quantity of freshwater resources affect mainly the rural population. In 1994, it was reported that 206 people had paludism, 3 582 people had epidemic hepatitis and 1 108 people had bilharzia (Table 10) (ONEM 2001).

In the Senegal and Gambia rivers, for example, it has been reported that aquatic weeds have increased due to construction of dams and therefore navigation has been restricted. Habitats for migratory birds have also been affected due to dam construction. Similarly, fish composition has been altered. Conflicts in uses of the resources within the watercourse do occur, but with limited intensity. In Senegal, modification of the hydrologic regime of the Senegal River as a result of

Table 10 Water-borne diseases in Morocco 1990-1994.

Disease	Number of affected people				
	1990	1991	1992	1993	1994
Paludism	838	499	405	198	206
Epedimic hepatitis	2 357	2 286	2 586	2 502	3 582
Bilharzia	3 487	3 705	2 358	1 137	1 108

(Source: ONEM 2001)

damming increased agricultural productivity downstream, but this was achieved at the expense of livestock husbandry that had traditionally been carried out in the flood plains. This upstream-downstream shift in resources also created potential bilateral conflicts between Senegal and Mauritania, as reported by Niang (1999). Persistent conflicts are mostly common among the pastoral and nomadic livestock keepers in Mauritania and Mali. As mentioned earlier, freshwater shortages contribute significantly to economic and health problems. Naturally, these factors are inter-related and in essence, the most common impact on the communities is an aggravation of poverty. People have moved away from traditional lands due to shortages of freshwater, which results in changes in community lifestyles. In Africa, per capita consumption rates of fish are very high, and millions of consumers count on inland fish as a major source of protein, making this resource important for food security (Ticheler 2000). While marine fisheries production is increasingly entering export markets, inland fish production largely continues to feed local populations. However, in the Canary Current region, the assessment showed that the degree of severity of the freshwater shortage is small and localised. The frequency and duration of the impacts is still short term with seasonal variations.

Conclusion and future outlook

The current environmental status of freshwater shortages in the Canary Current region shows that there are significant impacts due to stream flow modification, pollution of existing supplies and changes in the water table. High population rates, urbanisation with limited additional infrastructure, industrialisation and agricultural development are among the major contributors to the problem, as well as the beneficiaries of the resources. Many transboundary rivers have multiple dams that cause environmental problems. Due to shortage of surface water, many countries continue to extract groundwater for various needs. The number of people affected (in terms of economics, and social and health effects) is high particularly in the Canary Current South sub-system.

In the future, an increase in water demand for irrigation, drinking water and industrial water associated with a decrease in water supply due to drought will put pressure on available water resources. As a consequence, more river regulation to provide additional water storage will likely result. In fact, Morocco has already more than 90 large and small dams and the authorities are planning more construction the next 20 years (ONEM 2001). In addition, countries will be more likely to look to redistribute water through inter-basin transfer. Again in the case of Morocco, inter-basin transfer options from north to south have been considered since the beginning of the 1990s (CSE 1988). The water demand for the Greater Dakar region is expected to grow by 30% over the next decade, and triple over the next 30 years (at an annual growth of about 3%) (AWRMI 2001).

In general, in the majority of the countries of the region, there is a growing concern and awareness about water shortage and scarcity as well as about drought and the effects of climate change on water resources. Several measures have been taken since the middle of the 1980s and the beginning of 1990s. Such measures include campaigns aimed at the general public about the importance of conserving drinking water, actions to implement more efficient water use practices in irrigation, development of improved water harvesting methods in rain-fed areas and the use of wastewater for irrigation. In Morocco for example, since the beginning of the 1990s, the General Department of Hydraulics has been developing a comprehensive, flexible water resources master plan for the country's major river basins. Moreover, the institutional framework and setting for water resources management and development such as the creation of river basin agencies, a consultative national council for water and climate, and various water regulations are being launched.

Pollution

 **Canary Current North** **Canary Current South**

Eutrophication due to pollution has been identified as a problem, particularly in the Canary Current South sub-system. Furthermore, chemical pollution and suspended solids were also ranked as a major problem in the Canary Current region as a whole. Microbiological pollution and oil spills were assessed as slight in the Canary Current South sub-system. In the Canary Current North sub-system, the problems encountered are chemical pollution, suspended solids from agriculture (from the use of fertilisers and pesticides in major irrigated perimeters in the major watersheds) and industrial activities. Pollution along and in the Atlantic waters is a transboundary problem and affects all the other Atlantic coast countries in the region (The Gambia, Mauritania and Morocco). The most critical problem in Cape Verde is marine dumping, especially hazardous wastes.

For other GIWA issues, such as thermal and radionuclide pollution, there is no evidence or data concerning these activities in the region. There is some evidence of minor spills of hazardous materials, but these are limited to harbors and fishing ports (UNEP 2002). These issues are therefore not further discussed.

Box 4 Pollution in the city of Dakar.

Senegal's industrial enclave is along the Hann Bay in the capital city of Dakar, which is also the most populated area in the whole country. Some of these industries involve highly toxic chemicals that are used in the production of paint, textiles and pharmaceuticals. There are also fish, slaughterhouses and food processing industries. The 1999 Japanese International Development Cooperation Report on the status of the environment in Senegal noted that raw surface waters were highly polluted. The report noted that this pollution was concentrated along the densely populated Hann Bay in Dakar where 30% of the industries discharge their waste directly into the bay (30%), 12% is discharged through sewers, 12% is discharged after pre-treatment and 4% passes through septic tanks or in open sites. The total amount of wastewater discharged is estimated to be 41 000 m^3 per day. Run-off from agriculture also contributes very significantly to pollution of water, as can be observed in Lake Guiers, and the Senegal and Casamance Rivers. Tourist facilities along the Atlantic coast also discharge to waters, and oil spills can be observed around oil refineries in Dakar

(Source: JICA 1999)

Environmental impacts

Microbiological

Coastal cities in the region such as Dakar, Nouakchott, Banjul, without adequate sanitation and waste treatment facilities, are hubs for microbial pollution. In addition, these coastal cities are primary centres of industrial development and a high population density (Arthurton et al. 2002). According to the African Environmental Outlook (UNEP 2002), microbial and bacteriological contamination is a particular concern in the Hann Bay, near Dakar (Senegal) (See Box 4). Water-borne diseases due to microbiological pollution for the Canary Current South sub-system are listed in the section on health impacts of pollution.

Eutrophication

The assessment of eutrophication is based on the artificially enhanced primary productivity in receiving water basins as related to the increased availability or supply of nutrients. In the Canary Current South sub-system the increasing proliferation and invasion of aquatic species (*Typha australis, Salvinia molesta*) forming green carpets on the water surface along the rivers and particularly in the Senegal River Delta is partly as a result of increased nutrient loading. Under such conditions biological resources (fish and plants, in particular) are affected (Tandia & Dieng 2001). The decay of organic matter depletes oxygen particularly in areas around major cities, the bays and ports, creating anoxia and fish mortality (Tandia & Dieng 2001). In addition, some toxic algae in Lake Guiers have been reported (Tandia & Dieng 2001). The problem of eutrophication has been assessed as having moderate impacts in the Canary Current South sub-system.

For the Canary Current North sub-system, eutrophication effects are to certain degree only found in large dam reservoirs. This is due mainly to pollution loads and the use of fertilisers upstream of reservoirs, which increase the presence of algal blooms that in turn result in a deterioration of the quality of drinking water. As an example, in Sidi Mohammed Ben Abdellah reservoir, which supplies Rabat City in Morocco, 98% of the phosphorus and 85% of the nitrates originate from fertiliser uses upstream of the reservoir (ONEM 2001).

Chemical

Like most rivers draining deserts, the Senegal River contains some salt. The level increases sharply between December and June and drops towards the end of July. There is no regular monitoring of chemical pollutants in the region neither in inland nor in marine waters. However, the intensive use of pesticides and fertilisers in the agricultural and irrigated areas in the region (Morocco and Senegal River valley for example), is a well-known fact. In 2001, the agricultural sector in Morocco used 8 500 tonnes per year of nitrogen as a fertiliser. This use is expected to climb to 15 200 tonnes per year by the year 2015. In addition, it has been reported that nitrate concentrations in several wells in the Oum Errabia Basin are more 50 mg/l with a yearly increase of 5 mg/l. It is also estimated that 0.5 to 1% of the total pesticides used in Morocco reach the country's rivers via run-off (ONEM 2001).

Suspended solids

The region is characterised by desertification, overgrazing of fragile ecosystems, cultivation of crops on steep slopes (Cape Verde), and soil erosion. These anthropogenic activities lead to run-off and increases in turbidity in the major rivers and lakes in the region.

Data on suspended solids for the Gambia and Senegal rivers in the Canary Current South sub-system is shown in Table 11. Fundamentally, these statistics show that the Senegal River has a fairly high concentration of suspended solids (196 mg/l) compared to other major African rivers. In contrast, the Gambia River has low concentrations, amounting to only 19.5 mg/l (Martins & Probst 1991). In terms of total dissolved solids, the two rivers have minimal levels, especially in comparison with other major African rivers.

In the Senegal River and Lake Guiers, total suspended and total dissolved solids are increasing. In particular, total suspended solids are quite significant in the Senegal River and fairly moderate in the Gambia River. The cause for these loads are partly due to increasing

Table 11 Suspended solids in the Gambia and Senegal rivers.

River	Precipitation (mm)	Run-off (mm)	RC (%)	TDS (mg/l)	TSS (mg/l)	Transport (million tonnes)		TSS/ TDS
						TDS	TSS	
Gambia	1 100	219	20	17	19.5	0.08	0.09	1.10
Senegal	650	48	7	42	196	0.4	1.9	2.44

Note: RC = Run-off coefficient. TDS = Total Dissolved Solid. TSS = Total Suspended Solid.
(Source: Martins & Probst 1991)

Box 5 Damming of the Sebou River.

Sediment fluxes of the Sebou River were estimated based the on suspended sediment load transported by the River to the coast. The study reported an exceptionally high sediment yield (850 tonnes/km^2/year) before the construction of the dams. The sediment load was due to the combination of steep slopes that generate landslides and mud flows, easily eroded material, high precipitation and human activities such as vegetation removal and change in land use. It was estimated that the sediment load from 1940 to1972 before the construction of dams was about 34 million tonnes per year. After the construction of five dams on the River, the sediment yield was not more than 1.36 million tonnes per year. Thus, more than 95% of the River's sediment load was trapped by these dams. In addition, damming of the Sebou River appears to have had a pronounced effect on the coastal zones, which reached a new dynamic equilibrium in response to the changed sediment regime. The estuarine behavior of the lower stretches of the River downstream of the dams has greatly disturbed the river outlet topography and coastal stability.

(Source: Arthurton et al. 2002)

anthropogenic activities as described earlier, and partly because of the decrease in stream flow following the construction of Manantali and Diama dams.

In Morocco, dam siltation is a problem, where the country's agricultural output is dependent on irrigated farming. Siltation has reduced dam storage capacities and reduced the life span of dams. It is estimated that 50 million m^3 in storage capacity is lost annually, or about 0.5% of the total design storage capacity of the existing dams (Box 5). To date, a total of more than 820 million m^3 of the total storage capacity has been lost (ONEM 2001). Morocco loses an estimated 22 000 ha of arable land annually. Deforestation contributes to this problem with an annual loss of 31 000 ha of forested land, of which more than two-thirds is used for firewood. The impact of soil erosion on water quality is significant (ONEM 2001).

Solid wastes

Household and industrial solids wastes are discharged directly into rivers and the ocean which in turn results in the deterioration of water quality. In Senegal, the amount of solid waste generated throughout the country is estimated to be 744 250 tonnes per year, of which 280 000 tonnes are generated in Dakar (JICA 1999). Due to the lack of household waste collection, most domestic wastes remain in the streets, open canals or illicit dumpsites throughout the city. The problem also affects the coastal beaches, giving rise to public concern about recreational use.

The quantity of municipal wastes generated per inhabitant per day ranges between 0.4 and 0.9 kg/inhabitant/day in Morocco, where solid waste collection ranges from virtually nonexistent in rural areas to as much as 85% in the major cities of Casablanca and Rabat. The rate of waste collection is relatively satisfactory, and could range between 70 to 90% (ONEM 2001).

Even where collection is not a problem, disposal through uncontrolled dumping remains the norm. There are no specific provisions for industrial, toxic, hazardous and medical wastes in the region, although larger medical facilities own and operate incinerators. In Morocco, municipal waste totaled 3.7 million tonnes in 1992, of which 2% is recycled through an informal recycling sector (UNEP 2002).

Socio-economic impacts

The economic sectors affected by pollution in the Canary Current region are agriculture, fisheries and tourism. Impacts on fisheries and agriculture sectors can have severe economic effects beyond direct losses since these sectors contribute very significantly to the overall national product (more than 30% of GDP in the region). Pollution along the coast near densely populated cities such as Dakar are a major cause for losses of up to 40% in tourism industry in this country. Pollution adds additional costs for water purification in major cities, as well as for alternative supplies. In Morocco for example, the increase in suspended sediment concentrations in reservoirs requires the use of primary clarification procedures, which adds to the treatment cost per cubic metre.

In a small fishing village in the district of Hann (Dakar region), 35% of the patients examined by physicians at the university hospital have skin disease. It is believed that the skin disease is from marine water pollution due to industrial activity in the Hann Bay. A limited number of cases of poisoning, mainly in children, have also been reported. These problems were due to the grilled fish consumed by children (Dieng pers. comm.).

The people affected are those who live near polluted water, the people who consume fish or shellfish from polluted water bodies, and the people who swim in these waters. The number of communities affected and their size, the degree of severity and the frequency and duration have been judged to be limited, and were considered slight in both two sub-systems.

Conclusions and future outlook

For the last decade there has been growing concern about water quality and pollution in general in the region. But governmental authorities are to a certain degree much more concerned with water quantity and supply and other social problems. This lack of concern and therefore mitigation will likely lead to the deterioration of water supplies due to urbanisation, migration, a greater concentration of population and industries, intensification of agricultural production, an increase in irrigated areas and poor land use practices upstream of the different major basins in the region. Pollution in the Canary Current

region will therefore worsen over the next 20 years. The environment impacts of this pollution will be moderate to severe. It is expected that problems resulting from pollution from eutrophication, microbiological and chemical sources, solid wastes and suspended solids will worsen the most.

Habitat and community modification

 **Canary Current North**  **Canary Current South**

There has been considerable loss and degradation of both aquatic and terrestrial habitats in the region during the last two to three decades. The impact has been partly due to natural factors such as drought but significantly due to human activities such as poor and unsustainable agricultural practices, urbanisation, mining, industrial development and other natural resources use.

Environmental impacts

Loss of ecosystems or ecotones

Despite being among the most biologically productive ecosystems in Africa, wetlands are often regarded locally as wastelands, habitats for pests and threats to public health or as potential areas for agriculture. As a result many wetlands are being lost (UNEP 2002). The combined effect of drought and ever-increasing human activities (afforestation, deforestation, alien encroachment, overgrazing, and river regulation affecting and reducing water supply for riparian vegetation) has contributed to the loss of specific types of wetland habitats; marshes, swamps, and mangroves over the past two to four decades.

To date, approximately 30% surface area of these and other wetland habitats have been permanent destroyed in the Canary Current South sub-system (UNEP 2002). Examples of these include: the Niayes wetlands in Senegal, lakes in The Gambia and Senegal, and mangroves in Senegal (Sine Saloum). In Mauritania, wetlands ecosystems such as pools and creeks have disappeared.

The combined impacts of human activities and drought on these types of habitats are quite significant. Due to prolonged droughts in the northern and interior part of the region, open and running water ecosystems have suffered tremendous losses (Tandia & Dieng 2001). Eutrophic lakes in particular, have disappeared. In the Canary Current South sub-system, most eutrophic lakes (except those lakes close to or in contact with Senegal River) have disappeared.

In the Canary Current North sub-system, lakes in the Atlas Mountains, for example, are drying up very fast due to natural and anthropogenic causes (ONEM 2001).

Modification of ecosystem or ecotones

Ecosystems that have not been destroyed are being modified because of continuing human activities. Examples include: modification of the tannes (wetlands) in Senegal, and the proliferation of rodents and aquatic weeds in the Senegal River Basin valley.

The main change recorded for mangrove forests is its reduction in area, which is due to sulfato-acid soils. These soils are responsible for the replacement of mangroves by tannes (salted soils) in the Saloum estuary in southwestern Senegal. This is observed mainly in the central and eastern parts of the estuary where the number of dead mangrove increases until they completely disappear after Foundiougne. Together with this reduction in the area, there is a reduction in tree size (Diouf 1996). The mangrove in Casamance has retreated since 1970, although the figures are different depending on the authors. Sall (1982) observed that between 1973 and 1979 the area of tannes had increased by 107 km^2 while the mangrove area was reduced by 87 km^2. On the other hand, Marius (1985) estimated that 70 to 80% of the *Rhizophora* had disappeared since 1979. Badiane (1986) indicated a reduction of the mangrove area which had occupied between about 1 200 km^2 before 1968-1970 to 930 km^2 in 1973 and 830 km^2 in 1983. The *Rhizophora* were partly replaced by *Avicennia* but this species was finally reduced by hypersalinity.

According to Rue (1994), the observed retreat of the mangroves in Senegal could be related to the weakness of the fluviatile behavior of the rivers (linked to the diminution of freshwater flow, itself induced by the prolonged drought) that induces the growth of sand spits that delimit the estuaries, thus diminishing the entrance of seawater into the estuary. This, in turn, favours salt penetration in the soils thus allowing the development of tannes. It also limits the possible extension of the mangroves as well as the area able to be inundated. This, combined with a lack of pelitic inflow, contributes to the reduction of the area covered by mangroves.

Another modification of the mangrove community in the estuarine system of Senegal was observed due to the breaching of the Sangomar sand spit in 1987. Significant quantities of sands coming from the coastal erosion of the ocean side of the spit accumulated partly in the external fringe of the mangroves, just in front of the new mouth. This substrate change is responsible for the death of the mangroves. In addition, data indicate the extension of water lilies in estuaries and bays, particularly

due to flow alteration and reduction, along with the frequency, intensity and timing of flood events, inappropriate development, pollution from a number of sources, and overexploitation, all contribute to the modification of estuarine systems in the region (UNEP 2002).

In the Canary Current North sub-system, continental wetlands in Morocco are being degraded, and marshlands in the northwestern part of the country (the Gharb area) and Sebkha in the southwest (Draa area) have dried up and been cultivated (ONEM 2001). In addition, there is some evidence of change in species composition resulting from species extinction or introduction. Reports indicate the extension in the 1970s of two well-known bird species, one of which is the rosy flamingo (*Phoenicopterus rubber)* in the Iriki water empoundment in the lower Draa River valley due the construction of El Mansour Eddahbi Dam upstream (ONEM 2001). In the case of certain lagoons in the Atlantic Ocean there has been a progressive extinction of certain endemic algae species such as *Psidona oceanica* due to proliferation of *Caulerpa prolifera*. Another example is the introduction of a red algae species *(Antithamnion algeriensis* and *Asparagopsis armata)* in certain lagoons (ONEM 2001).

Because of this ecosystem and ecotone modification, several species are being threatened. Table 12 shows the number of endangered species in the respective countries of the region.

Table 12 Threatened species in the Canary Current region.

Country	Taxonomic group								
	Mammals	Birds	Reptiles	Amphibian	Fishes	Mollusks	Other inverte-brates	Plants	Total
Cape Verde	3	2	0	0	1	0	0	2	8
Guinea	12	10	1	1	0	0	3	21	48
Guinea Bissau	3	0	1	0	1	0	1	4	10
Mali	13	4	1	0	1	0	0	6	25
Mauritania	10	2	2	0	0	0	0	0	14
Morocco	16	9	2	0	1	0	7	2	37
Senegal	12	4	6	0	1	0	0	7	30
The Gambia	3	2	1	0	1	0	0	3	10

(Source: IUCN 2002)

Socio economic impacts

Loss of wetlands usually means the loss of vital functions they play in nature vis-à-vis, spawning areas for fish, improving water quality through the purification mechanisms, and other ecological functions. All these losses translate into high economic costs for the national as well as household economies. Similarly, loss or modifications of wetlands translate to losses of revenue from livestock, wildlife losses, damage to fisheries and tourism, and high costs in terms of loss of water quality. Finally, losses or transformation of wetlands leads to shortage of wood for fuel, which is very vital to the majority of households in rural areas of the region. The size of the population affected is very important since all the countries in the region are relying mainly on agriculture. The degree of impact is different according to the area within the region or even within the country. In the northern Senegal valley, ecosystem loss greatly affects agriculture (animal husbandry). In other regions in Senegal, the energy sector is affected due to wood loss. The loss of natural ecosystems that attract tourists costs these countries dearly.

Wetlands and other aquatic as well as terrestrial resources are the sources of livelihoods for majority of people in the region, so any type of impact translates to the loss of livelihoods and suffering, even illness. Loss and degradation of habitats compromises water quality as wetlands generally act as sinks for pollutants from land-based activities. These impacts in turn escalate health problems.

Against this backdrop, the assessment recognised that a greater percentage of the population in the Canary Current South sub-system suffer from these impacts as compared to the North. Intestinal bilharzia in Senegal, for example, erupted after the construction of Antisel Dam at Diama, because the dam created favorable conditions for the mollusks that are the intermediate hosts for the organism. The infection can result in some hepatic complications for children and adults. The risks of complication are linked to the intensity of the infection; serious pathologies have tendency to be concentrated in communities where the prevalence of the organism is greatest. In certain villages along the Senegal River, infections can sometimes reach a rate of 75%, as is the case in Richard Toll, a village close to Lake Guiers (Tandia & Dieng 2001). Urinary bilharzias associated with complications of impotence among men and sterility among women is widespread particularly in Tambacounda region, where 385 982 inhabitants (with a prevalence rate of 80%) are affected (Tandia & Dieng 2001). Onchocercciasis is widespread southeast of Tambacounda, Kolda, in an area that includes 456 villages. The disease is caused by organisms whose larvae develop in running water. In Senegal, 200 000 people are exposed, 65 000 are infested and 2 800 are blind. In Guinea, out of 510 000 recorded cases, 9 000 are blind; in Guinea-Bissau, out of 3 300 cases recorded, 100 are blind; and in Mali, out of 196 000 cases recorded, 2 700 are blind (Tandia & Dieng 2001). Trypanosomes are re-emerging in certain countries where it had disappeared. Changes in the ecosystem have created a favorable environment for the tsetse fly. Currently the disease is widespread in Guinea-Bissau.

In the Canary Current South sub-system, the impacts are significant, because of the large numbers of affected people, and the sectors that are involved. These impacts include: migration (occasionally even transboundary migration), conflicts, and settling of nomads. In Mauritania for example, the number of nomads decreased from 60% to less than 5% in less than 15 years (Diop 2001).

Conclusions and future outlook

Some habitats and communities are already lost, so that the remaining are becoming more important for the region. A social awareness about marine resources is starting to develop, helping to stop their degradation. As regards continental habitats and ecosystems, conservation areas are being created and some restoration is taking place in the currently degraded areas. The majority of the countries in the region are altering their regulations and have already adhered to or are in the process of adhering to international conventions. For example, Morocco has already ratified the Convention on Biological Diversity and 50 others conventions related to the preservation of the environment such as the International Trade Convention on Endangered Species, Ramsar, and Framework Convention on Climatic Change to name just a few (see Table 7). The Task team that evaluated the environmental impacts of habitat and community modification knows as a result of this that an improvement over the next 20 years can be expected but the impacts of the current degradation will likely still be moderate.

The countries in the region have responded to the problems of habitat loss by placing natural areas under protection. However, the number and size of protected areas varies from country to country. At present there are 42 national terrestrial protected areas in the region, with a combined area of more than 5.5 million ha and 30 marine protected areas (World Bank 2001). Details of national and international protected areas are given in Table 13.

International efforts to conserve natural habitats have been very successful in these countries, mainly as a result of ratification of the Ramsar Convention, and the Convention on Biological Diversity. There are eight Biosphere Reserves in the region, four World Heritage Sites, and 18 Ramsar sites. Many more sites are proposed for protection (Hegazy et al. 2001). However, in spite of such efforts, the total area officially declared as protected in the region remains less than the international target of 10%, although some countries are aiming to increase their protected areas to more than 15% within the next three decades.

Unsustainable exploitation of fish and other living resources

 **Canary Current North**  **Canary Current South**

Fishing activities in the region have increased for the last three decades with the pressure from the industrial and traditional flotilla from European and Asian countries as well as from fleets originating in the respective countries themselves (Figure 9). The marine fisheries sector in the region is characterised by operations at industrial and artisanal levels which target pelagic and demersal stocks. These stocks constitute vital renewable natural resources that provide food and income for local populations, revenues for the national governments, foreign exchange earnings as well as employment opportunities.

Environmental impacts

Overexploitation

Overexploitation currently constitutes a major issue in the majority of the countries in the Canary Current region. Fish catches in many countries of the region have shown a systematic decline since 1974.

Table 13 National and international protected areas in the Canary Current region.

Country	National protected area				International protected area					
	Terrestrial			Marine	Biosphere Reserves		World Heritage Sites		Ramsar Sites	
	Number	Area (ha)	Land area (%)	Number	Number	Area (ha)	Number	Area (ha)	Number	Area (ha)
Gambia	6	23 000	2	5	0	0	0	0	1	20 000
Guinea	3	164 000	0.7	1	2	133 000	1	13 000	6	225 000
Guinea Bissau	0	0	0	2	1	110 000	0	0	1	39 000
Mauritania	9	1 746 000	1.7	5	0	0	1	1 200 000	2	1 231 000
Morocco	12	317 000	0.7	10	2	ND	0	0	4	14 000
Senegal	12	2 181 000	11.1	7	3	1 094 000	2	929 000	4	100 000
Total	42	4 431 000	16	30	8	1 337 000	4	2 142 000	18	1 629 000

Note: ND = No Data. Data not available for Cape Verde. Some Biosphere Reserves are also World Heritage Sites or Ramsar sites.
(Source: Ramsar 2002, UNDP 2000, UNESCO 2002, World Bank 2001)

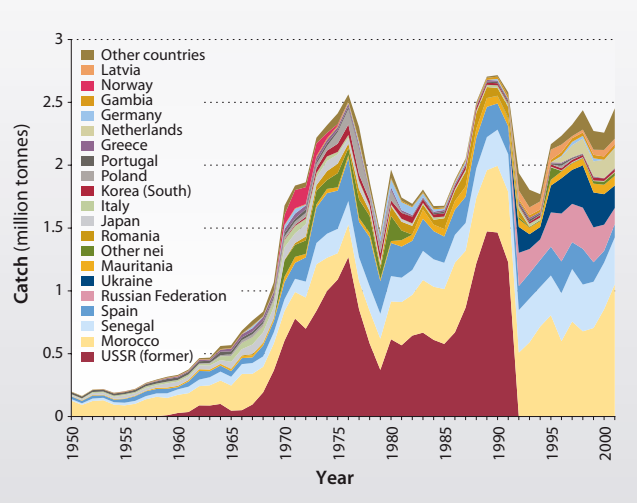

Figure 9 Fish catch in the Canary Current Large Marine Ecosystem.
(Source: LME2005)

Uncontrolled exploitation of the fisheries by foreign vessels is also leading to the depletion of some fish stocks. It has also been observed that the Gambian dermesal production over the past decade has been near and even above the 15 000-17 000 tonnes MSY set for dermesal fish (Tables 14 and 15).

Table 14 Maximum sustainable yield for fish stocks in Gambia, 1997.

Stocks	Maximum sustainable yield (tonnes)
Pelagics	65 000-75 000
Dermesals	15 000-17 000
Crustaceans & other shell fishes	1 000
Total	80 000-92 000

(Source: Gambia Fisheries Department 2002)

Table 15 Fish production in Gambia 1990-1999.

Year	Industrial production (tonnes)	Artisanal production (tonnes	Total (tonnes
1990	18 486	2 793	21 279
1991	19 564	2 087	21 651
1992	4 822	1 312	6 134
1993	6 843	2 519	9 362
1994	6 767	2 398	9 165
1995	6 049	85 170	11 219
1996	7 302	6 172	13 475
1997	6 131	6 673	12 803
1998	5 043	3 507	8 550

(Source: Gambia Fisheries Department 2002)

Table 16 Fishing potential and exploitation of the main stocks in Cape Verde.

Stock	Estimated total allowable catch (tonnes)	Expansion potential (tonnes)
Tuna species	25 000-30 000	17 500-22 500
Small pelagics	10 000-12 000	7 600-9 600
Dermesal	3 000-5 000	2 100-4 100
Lobster	50-70	Fully exploited
Total	38 000-47 000	27 200-36 200

(Source: INDP 1999 in Fonseca 2000)

Table 17 Fishing potential and exploitation status of fish stocks in waters off Senegal and Mauritania.

Fish stock	Senegal (tonnes)		Mauritania (tonnes)	
Large pelagics	15 000-20 000	Fully exploited	1 000	ND
Small pelagics	200 000-450 000	Moderately exploited	800 000	Moderately exploited
Dermesal	130 000	Slightly overexploited	12 800	Slightly overexploited
Total	545 000-700 000		813 800	

Note: ND = No Data.
(Source: FAO 1997 in Fonseca 2000)

Discussions between the European Community and a number of the countries in the region for the renewal of fishing agreements are under way. With the exception of Cape Verde (Table 16), the intensification of fishing activities in the region has had a drastic impact on the state of fisheries resources such as pelagic fish, which notably underwent a strong decline in productivity (Table 17). The infection of coastal waterways by floating weeds has also led to a decline in fisheries activities due to clogging of waterways, estuaries and lagoons.

Stocks in Senegal and Morocco have also experienced overexploitation. Figures 10 and 11 illustrate the fishing effort as well as the catch for the Pink shrimp (*Parapenaeus longirostis*). The recorded landings of Moroccan fisheries in the Atlantic increased by a factor of two from 1950 (139 700 tonnes) to 1974 (264 300 tonnes) and a factor of five from 1950 to 1998 (708 700 tonnes). This substantial increase was due to increase in the fishing effort for all fleets (small-scale, coastal and industrial) and to the addition of the Western Sahara catches in 1975. During the period 1985-1998 demersal species were dominants; their catch increased from 5 400 tonnes in 1985 to 23 700 tonnes in 1998. The octopus catch increased from 3 000 tonnes in 1993 to 15 000 tonnes in 1998. The catch of sparids (Seabreams) decreased from 13 124 tonnes in 1984 to 3 240 tonnes in 1998, suggesting that these species may be overfished. The total catch of small pelagic species in Morocco increased from 110 800 tonnes in 1995 to 485 500 tonnes in 1998 (Baddyr & Guénette 1998).

For more figures and data on overexploitation in the Canary Current region, please refer to the Causal chain and policy option sections.

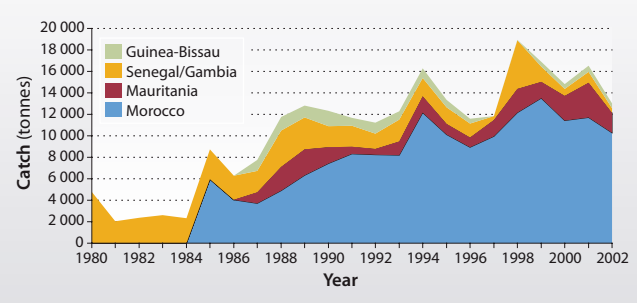

Figure 10 Catch of Pink shrimp (*Parapenaeus longirostris*) in the Canary Current region.
(Source: Diop 2001)

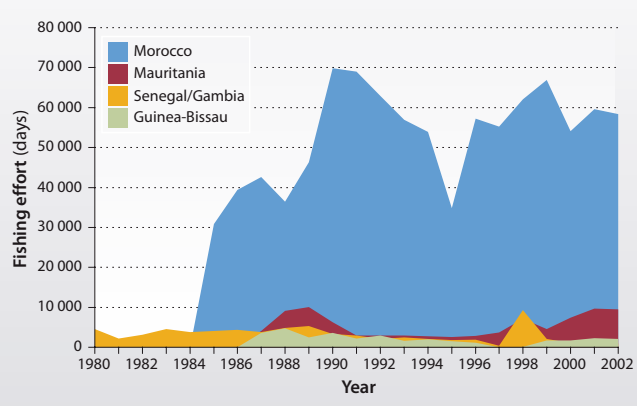

Figure 11 Fishing effort for Pink shrimp (*Parapenaeus longirostris*) in the Canary Current region.
(Source: Diop 2001)

Table 18 Unreported landings and discards in Morocco.

Fleet	Fishery	Unreported landing and discard		
		1970s	1980s	1990s
Unreported landings (% of total landing)				
Coastal	All	23 (Assumed)	23 (El Hannach , 1986)	47-60 (El Mamoun 1999, Durand 1995)
Industrial	All	ND	47 (Assumed)	47-60 (Durand 1995)
Discards (%of total catch)				
Coastal	Pelagic	ND	4 (Assumed)	4 (El Mamoun 1999)
	Dermesal	ND	ND	12 (El Mamoun 1999)
Industrial	Dermesal trawlers	66 (Balguerias 1997)	46 (Balguerias 1997)	30 (Haddad 1994)

Note: ND = No Data.
(Source: Baddyr & Guénette 1998)

Excessive by-catch and discards

By-catch and discards are mostly caused by the use of net types that capture fishes that are later considered to be undesirable, a problem that is especially common in traditional fishing. Table 18 shows the percentage of unreported landings and the discard rate by decade in the case of Morocco. In 1984, the unreported landing of the coastal fisheries was estimated at 23% of the total reported landings in the port of Tangier, Casablanca and Agadir (El Hannach 1986). In 1999, a study using direct observations and a fishers' survey described the illegal trading of fishery products (El Mamoun 1999) and showed that, except for Tangier, landings arrived from boats or transiting through ports are reported in a larger proportion (30-60%) than those being transported by trucks (12%). Underreporting seemed to be more important for cephalopods and crustaceans. The difference between the results obtained in 1984 and 1999 is large and most likely corresponds to a change in social and economic incentives in Morocco. Prior to the 1990s fish were not consumed much by the local population, thus the opportunity to sell fish locally and directly was scarce. In the 1990s demand for fish increased sharply at the same time as the human population increased, and refrigerated transport facilities increased.

Studies of discards in the Atlantic Coast of Morocco for the Spanish cephalopod commercial trawl fishery documented large rates of discards (Balgueiras 1997). The species composition of the discards was dominated by invertebrates other than cephalopods (16-28%), Sea breams (4-9%), Elasmobranchs (5%), Triglidae (Searobins, 10%) and various other dermesal species (Haddad 1994). In comparison, Mauritania cephalopod trawlers fishing in Mauritania and Senegal were found to discard 72% and 60-75% of their catch respectively, while the Senegalese mixed fleet (which was targeting finfish and shrimp in shallow waters) had a discard rate of 67% (Balguerias 1997). As an indication of the changes in the shrimp fisheries, Senegalese shrimp trawlers operating in Senegal and Guinea are thought to have discarded 38.5% of their catch in the mid-1980s (Baddyr & Guénette 1998).

Destructive fishing practices

The use of destructive fishing practices such as explosives and inappropriate nets have been reported in the region (Deme et al. 2001, Dahou & Deme 2001). In spite of a prohibition against their use, explosives are employed by some fishers in the region, causing serious damage to the resource and to the environment. The use of the dynamite destroys the rocky zones that provide an essential breeding place for many species. In the same way, although prohibited by regulations, nets manufactured from monofilaments and multi-monofilaments elements are still in use in the artisanal fishing in the region. These nets are non-biodegradable and quite often are left in the ocean. Finally, the use of non-selective gear and small mesh size and the lack of respect for minimum fish weights accentuates

the overexploitation of fish resources in the region. Consequently, fish catches have decreased, prices for the producer have increased, local markets suffer disruptions in supplies, household food security is threatened, and the tensions between socio-professional categories for the access to the products has increased.

Socio-economic impacts

The economic difficulties caused by unsustainable exploitation of living resources are considerable given the fact that fisheries is an important sector in the economy of the region. Fisheries provide substantial momentum for the GDP of the various countries. Similarly, its contribution at the household level is significant in terms of employment, food and trade. Additionally, changes or losses in this sector can have severe repercussions for human health. Approximately two thirds of the population of the Canary Current region lives in the coastal zone, and particularly in cities located on the Atlantic coastline. This heavy concentration is dictated by the search for employment that is readily available in industry, particularly the marine fishing industry.

Unsustainable exploitation of living resources harms the fisheries sector and leads to unacceptable levels of environmental degradation. Considerable numbers of people are employed in this sector, such as fishermen, traders and processors, the majority of whom bear the burden of any environmental degradation. Degradation in the sector translates into significant negative impacts on employment. Loss of employment translates into impoverishment and suffering of people, mostly among vulnerable groups such as women, children and the elderly. Fish processing industries suffer when overexploitation takes place because it means that these industries operate below capacity. There are negative impacts on state income, losses in the fishing industry, reduction of food supply, the increase in costs for inshore maritime surveillance, the loss of biological diversity and loss of employment.

Overexploitation of living resources results in a reduction of protein sources, since the majority of fish are exploited for export, leaving a bare minimum for the local market. This in turn contributes to the accentuation of protein deficits, particularly for small children, through nutritional diseases such as kwashiorkor (protein-caloric malnutrition disease), which is a widespread problem in the Canary Current South sub-system. This malnutrition is accentuated mostly in rural areas where livestock (sources of protein) are under severe threat from droughts brought about by the vagaries of climate change. In the Canary Current North sub-system, few people are affected by this concern.

Unsustainable exploitation of fish leads to a decrease in the commercial viability of fishing activities, and results in unemployment, particularly for younger people, who may find themselves without any job opportunities. This condition results in increased cases of delinquency and poverty. Loss of employment in the fishery sector in Senegal may be as high as 80%. Unsustainable exploitation of fish also leads to bitter competition among different user groups (Deme et al. 2001).

Conclusion and future outlook

The major issue in the Canary Current region is presently overexploitation. Most if not all the coastal countries are already taking steps in terms of regulating the use of the fish stocks at the national and international level as demonstrated by discussions with the European Community regarding the renewal of fishing agreements with the different countries in the region. All these countries have determined that there is overexploitation of their fish stocks and have therefore determined that the ecosystem needs a rest. In addition, government fisheries institutions that used to be departments in the Ministry of Agriculture have been elevated to the status of their own Ministry of Fisheries. In addition, there is a growing concern and awareness of the need for conserving fisheries and improving management and control. In the region, fisheries authorities have instituted certain policy measures to control industrial fishing pressure by reducing the fishing effort. Since the beginning of the 1990s, governments have been implementing a policy of gradually reducing the number of licenses issued annually to fishing vessels. Table 19 shows an example from The Gambia.

Table 19 Licensed vessels in Gambia 1993-1997.

Type of vessel	Number of vessels				
	1993	1994	1995	1996	1997
Tuna purse seiner	23	18	15	1	0
Tuna long liner	31	8	5	7	1
Shrimp trawler	30	16	15	17	9
Stern trawler	18	8	5	5	6
Pair trawler	0	0	2	6	3
Total	101	50	42	36	19

(Source: Gambia Fisheries Department 1998)

In addition, there has been a regional effort among countries to coordinate their different fisheries regulations under the framework of a committee called CSRP (Commission Sous Régionale des Pêches/ Under-Regional Fisheries Sub Committee). This committee includes Mauritania, Senegal, The Gambia, Guinea, Cape Verde and Guinea-Bissau.

Global change

Canary Current North Canary Current South

Environmental impacts

Changes in hydrological cycle and ocean circulation

Although global model simulations project little significant change to rainfall amount and its seasonal distribution in the region in the next two decades, models of run-off show slight reductions over the whole area, especially around the Mediterranean, leading to reduced water availability. Temperature increases will also increase water stress on crops across much of the region. Despite the fact that clear scientific evidence has yet to be provided, some analysists argue that drought frequency and severity have already increased in conjunction with climate change in the region, with dramatic impacts on water availability.

Predicted changes in rainfall amounts and distribution are much less reliable (Morton & Saer 2001). However, available information tends to indicate that in recent decades, some parts of the region have become wetter while other parts are now drier than they used to be. In Morocco, the rainfall pattern has varied with a rate of -7% to +0% in the northern region and about -7.5 to +2.8% in the southern part of the country.

Sea level change

A recent review of the scientific basis for climate change in the region (Morton & Saer 2001) suggests that small increases in temperatures across the region have occurred in recent decades, although lower than the global average median forecast of 0.35°C per decade, or 0.7°C by 2020 for the region as a whole (Alibou 2002). In Morocco, the use of several simulation models predicts temperature increases on the order of 0.7 to 1°C by 2020 (Alibou 2002). As a result, sea level would rise between 2.6 and 15.6 cm during the period 1990-2020. In the Canary Current South sub-system, there is also some evidence of sea level change, but without major harm to populations or organisms (Alibou 2002). However, the GIWA Task team pointed out that advanced erosion on small islands and flooding at Saint Louis (Senegal) obliged the authorities to build a protection dam. The same problem has been experienced by a community of fishers in the zone of the Arguin Bench in Mauritania.

Socio-economic impacts

The economic sectors mainly affected by drought are agriculture and fisheries and to a lesser extent industry and tourism. The impact on the agricultural sector is significant since both crop and animal production rely heavily on rainfall and changes in climate result in high variability and associated variability in yields. The agriculture sector contributes on average about 20% of the GDP for the entire region (19% for Morocco, 20% for Senegal, and 26% for Mauritania). Based on these statistics, it is clear that the single most serious economic impact of global change is on agriculture. Fisheries are also affected, as are tourism and wildlife. The public sectors affected include health, education and infrastructure (in the cases of flooding). Income from traditional agriculture, which relies on rainfall, has decreased by 10 to 15% in the last decades. Other costs include: construction of dams and inter-basin transfer schemes to supply water, the costs of alternative sources of water (especially by desalination), the costs of deepening wells and pumping. The different countries in the region have had to expend a great deal of effort and money to alleviate the impact of the drought and the desertification in order to limit migration, both within or out of the country.

Drought results in habitat and community modification (see section above), which in turn affects human health by promoting increased rates of urinary Bilharzias (with prevalences more than 80% in certain villages in the Senegal River valley and in Tabcounda region) (Tandia & Dieng 2001). This is equally true for other regions in Mali.

These impacts are felt by a large number of people: some migrate (occasionally even transboundary), there are conflicts, and nomads may be forced to abandon their lifestyle and settle down. In Mauritania, for example, the number of nomads decreased from 60% to less than 5% in less than 15 years.

Conclusions and future outlook

The impact of global change has a direct effect on freshwater. Freshwater shortage is therefore the main problem in most countries of the region. As predicted by the Intergovernmental Panel for Climate Change model simulations (IPCC 2001), water scarcity may be severely problematic as a result of changing climatic patterns in the region, with dramatic effects on the availability of drinking water. Global change would have a pervasive influence on future demand for, and supply and quality of freshwater in the region, and would add to the pressure on water and environment resources, as well as coastal systems currently under stress. The region's irrigation systems are also under stress. In nearly all countries of the region, irrigated agriculture is adversely affected by salinity and waterlogged soils. It is estimated that in some countries of the region, up to 50% of irrigated land suffers from some degree of salinity. Another issue is the overexploitation of groundwater. Indeed, global change would also affect the fauna and flora of habitats in the region and result in a great loss of biodiversity.

All sectors of the economy, environment and society may be vulnerable to one degree or another, where steps to increase the capacity to adapt

to greater climatic and hydrological variability, including more frequent flood and drought extremes are required.

Priority concerns for further analysis

Based upon this assessment, the main concerns and issues are freshwater shortage (stream flow modification, pollution of existing supplies and change in water table) and the unsustainable exploitation of fish. The concerns were ranked in descending order of severity for the two sub-systems as follows:

Canary Current North

1. Freshwater shortage
2. Unsustainable exploitation of living resources
3. Pollution
4. Global change
5. Habitat and community modification

Canary Current South

1. Freshwater shortage
2. Unsustainable exploitation of living resources
3. Habitat and community modification
4. Pollution
5. Global change

The ranking was based on overall scoring. The Canary Current South sub-system has been suffering from water shortage problems (modification of stream flow) for the last three decades and will most likely suffer in the next 20 years from water shortage. The annual discharge of the Senegal River shows a period of significant deficit after 1970. The percentage of reduction between the mean annual discharge over the years before 1970 and the deficient periods is more than 40%. The same tendency has been also reported for other major river basins in the region.

In the Canary Current North sub-system, the declining groundwater base flow is a major issue that is linked to the long dry periods (more than 30 years) that the region as a whole is experiencing. Data show that in the last two decades, the average aquifer draw down in the Souss-Massa River Basin varied from 0.5 to 1.5 m per year (CSEC 2001).

The environmental impacts of stream flow modification, water regime change and a dropping water table lead to very serious socio-economic impacts that often have significant transboundary implications. These socio-economic impacts include the loss of agricultural income and potential, the high costs associated with the construction of dams and inter-basin transfer schemes to supply water, the costs of alternative sources of water, and the cost of deepening wells and pumping, increases in water-borne diseases, and conflicts about water.

Unsustainable exploitation of living resources is also considered as a main concern in the Canary Current region. Most of the countries in the region bordering the Atlantic Ocean have important marine fish stocks. Fishing activities have increased for the last three decades with pressure of fleets from both the bordering countries as well as from the traditional and industrial fleets from European and Asian countries. The efforts of the state of the region to develop and use these fish stocks in a sustainable manner are limited by the lack of adequate manpower and financial and material resources.