Water and agriculture in the Maghreb

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Claire Jacobs and Kees van ‘t Klooster
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<th>Full Form</th>
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<tr>
<td>ABH</td>
<td>Agence du Bassin Hydraulique, Morocco</td>
</tr>
<tr>
<td>ADA</td>
<td>Agence pour le Développement Agricole, Morocco</td>
</tr>
<tr>
<td>AMU</td>
<td>Arab Maghreb Union (also UMA)</td>
</tr>
<tr>
<td>ANRH</td>
<td>Agence Nationale des Ressources Hydraulique, Ministère des Ressources en Eau, Algeria</td>
</tr>
<tr>
<td>BPEH</td>
<td>Bureau de Planification et des Équilibres Hydrauliques, Tunisia</td>
</tr>
<tr>
<td>CGDA</td>
<td>Conseil Général du Développement Agricole, Morocco</td>
</tr>
<tr>
<td>DDZASA</td>
<td>Direction de Développement des Zones Arides et Semi Arides, Ministry of Agriculture, Algeria</td>
</tr>
<tr>
<td>DHA</td>
<td>Direction de l’Hydraulique Agricole, Ministère des Ressources en Eau, Algeria</td>
</tr>
<tr>
<td>GDA</td>
<td>Groupement de Développement Agricole (Agricultural Development Groups), Tunisia</td>
</tr>
<tr>
<td>INAT</td>
<td>Institut National Agronomique de Tunisie</td>
</tr>
<tr>
<td>INRAA</td>
<td>Institut National de la Recherche Agronomique d’Algérie</td>
</tr>
<tr>
<td>INSID</td>
<td>Institut National des Sols de l’Irrigation et du Drainage, Ministère de l’Agriculture et du Développement Rural, Algeria</td>
</tr>
<tr>
<td>MADRPM</td>
<td>Ministère de l’Agriculture et de la pêche maritime, Morocco</td>
</tr>
<tr>
<td>MARH</td>
<td>Ministère de l’Agriculture et des Ressources Hydrauliques, Tunisia</td>
</tr>
<tr>
<td>MEC</td>
<td>Morocco Economic Competitiveness Program, Morocco</td>
</tr>
<tr>
<td>ONAGRI</td>
<td>Observatoire National de l’Agriculture, Tunisia</td>
</tr>
<tr>
<td>ONID</td>
<td>National Office for Irrigation and Drainage, Algeria</td>
</tr>
<tr>
<td>ONEP</td>
<td>Office National de l’eau potable, Morocco</td>
</tr>
<tr>
<td>ORMVA</td>
<td>Offices Régionaux de Mise en Valeur Agricole, Morocco</td>
</tr>
<tr>
<td>OSS</td>
<td>Observatoire du Sahara et du Sahel, based in Tunis</td>
</tr>
<tr>
<td>PNEEI</td>
<td>Programme National d’Economie d’Eau en Irrigation</td>
</tr>
<tr>
<td>PSP</td>
<td>Private Sector Participation</td>
</tr>
<tr>
<td>REME</td>
<td>Réseau des Entreprises Maghrébines pour l’Environnement</td>
</tr>
<tr>
<td>SASS</td>
<td>Système Aquifère du Sahara Septentrional</td>
</tr>
<tr>
<td>SEEEE</td>
<td>Secretariat d’Etat de l’Eau et de l’Environnement, Morocco</td>
</tr>
<tr>
<td>SONEDE</td>
<td>National Company for Water Exploitation and Distribution, Tunisia</td>
</tr>
<tr>
<td>UMA</td>
<td>Union du Maghreb Arabe (also AMU)</td>
</tr>
</tbody>
</table>
1 Introduction

This report assesses the current situation of water and agriculture in the Maghreb region and identifies the challenges ahead. Agriculture plays an important role in the development of the countries of the Maghreb. Agricultural reforms are high on the agendas. All Maghreb countries have developed strategies for agricultural development, either to increase export or to reduce their reliance on import of agricultural products.

A considerable part of the Maghreb region is suitable for food production, however agricultural growth is hampering. The ratio of agricultural exports to imports in the Maghreb fell in the past decades, and the countries are increasingly forced to import products from abroad, mainly cereals. The high cost of food imports is becoming a major problem.

The Maghreb region is for the Dutch agribusiness an interesting area, given its location close to the European market, the availability of agricultural land, and the growing consumer market. The need of the Maghreb to increase their agricultural production in a sustainable way strengthened the relations, and makes the Netherlands an evident partner.

North Africa is a region with high water scarcity. According to FAO the water scarcity has reached a critical point in the region, and severe drought is expected in the future. The highest concern goes to the agriculture sector as this sector is the main user of the available water. At the moment Algeria, Tunisia and Libya already suffer from severe water shortage, which is defined as less than 500 m3 per inhabitant per year.

The objective of this report is to present a reliable overview of the current status of water availability and agriculture, together with recent developments in the region, national and regional strategies of the countries, the challenges ahead and possible topics for collaboration. The information in this report is based on:
- Interviews that have been held in Algeria, Morocco and Tunisia, at government level, and with international organisations and donor agencies;
- Datasets and reports that that have been made available through government officials and national research institutes;
- Literature research and data collection from public sources and international network organisations such as FAO, GWP, Worldbank, Plan Blue, UNEP.

Scope of the study
The following should be mentioned with regard to the scope of the study:
- “Maghreb” in this report refers to the countries Morocco, Algeria, Tunisia and Libya; Mauritania is not part of this study.
- The study has a focus on water and the cultivation of food crops. Fishery and livestock production are not included in the study.
- The boundaries used in geographical maps are international recognized boundaries such as used in UN and FAO publications.

Acknowledgements
This report could not have been written without the useful information provided by interviews with individuals from the Ministries, national institutes and international organisations (Annex 1). Alterra is very grateful for their contribution and for the reports and documents that have been made available. In addition, the support of the Agriculture Office of the Netherlands in the Maghreb was highly appreciated.
2 Maghreb overview water and agriculture

2.1 Natural resources, population and climate

The Maghreb ("place of sunset" or "western" in Arabic) is the northern region of Northwest Africa and includes five countries: Morocco, Algeria, Tunisia, Libya, and Mauritania (Fig. 2.1).

Fig 2.1 Maghreb region (Source: http://www.maghreb-studies-association.co.uk/pix/map.jpg)

The Maghreb is home to 1 per cent of the global population as of 2010. The Maghreb countries are characterised by a young population: Young people under 30 years of age make up at least half of the population in the Maghreb (Magharebia.com). Although the total population growth is considerable in the Maghreb (Fig. 2.2), the rural population is stabilizing or even slightly declining.

Fig. 2.2 Projected population growth for the Maghreb countries (Source values: United Nations Secretariat, Division of the Department of Economic and Social Affairs, World Population Prospects: The 2010 Revision)
The unemployment rate among the young and well educated remains high and is growing in some countries of the Maghreb. This represents a real challenge on the political, social and economic level. Table 2.1 presents some basic demographic, economic and geographic characteristics of the Maghreb countries.

Table 2.1 Basic characteristics Maghreb countries (Source, unless indicated differently: The World Factbook CIA, update July 2011)

<table>
<thead>
<tr>
<th>Country</th>
<th>Population</th>
<th>Age structure</th>
<th>Natural resources</th>
<th>GDP per capita (PPP)</th>
<th>Renewable water resources km3 / year (source: Plan Blue 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>34,994,937 (July 2011)</td>
<td>0-14 years: 24.2% 15-64 years: 70.6% (2011 est.)</td>
<td>petroleum, natural gas, iron ore, phosphates, uranium, lead, zinc</td>
<td>$7,300 (2010 est.)</td>
<td>11.7</td>
</tr>
<tr>
<td>Morocco</td>
<td>31,968,361 (July 2011 est.)</td>
<td>0-14 years: 27.8% 15-64 years: 66.1% (2011 est.)</td>
<td>phosphates, iron ore, manganese, lead, zinc, fish, salt</td>
<td>$4,800 (2010 est.)</td>
<td>20.7</td>
</tr>
<tr>
<td>Tunisia</td>
<td>10,629,186 (July 2011 est.)</td>
<td>0-14 years: 23.2% 15-64 years: 69.3%</td>
<td>petroleum, phosphates, iron ore, lead, zinc, salt</td>
<td>$9,400 (2010 est.)</td>
<td>4.2</td>
</tr>
<tr>
<td>Libya</td>
<td>6,597,960 (July 2011 est.)</td>
<td>0-14 years: 32.8% 15-64 years: 62.7%</td>
<td>petroleum, natural gas, gypsum</td>
<td>$14,000 (2010 est.)</td>
<td>0.6</td>
</tr>
</tbody>
</table>

The Maghreb area is one of the most water-scarce regions of the world where rainfall is a major climatic factor. Geographically there are three regions to be distinguished:

- Northern, coastal areas;
- Inland areas with mountain ranges (Atlas, Rif) and high plateaus;
- The Sahara desert.

Climate varies highly in the Maghreb, and the region is divided in a Mediterranean (temperate) climate region in the north, and the arid Sahara in the south. The Atlas mountains on the region’s northern border are regarded as a “rainfall generator”, enabling plant life on the plateaus. The Sahara desert in the south receives little or no rainfall. With these extreme variations in geographic features, precipitation in the Maghreb is highly variable both in space and time (Fig. 2.3). The largest variation in rainfall is seen in Morocco, with amounts of more than 1000 mm in the northern mountain areas to less than 300 mm in the south. Rainfall occurs mainly in winter. Summers are characterised by high temperatures, favouring an intense evaporation and evapotranspiration.
The pattern of vegetation in the Maghreb largely mirrors the different climatic zones, with areas of high rainfall producing the greatest volume of biomass in the north. The World Wide Fund for Nature (WWF) identifies several distinct eco regions in the Maghreb, grouped into the “Mediterranean Maghreb” that share many species of plants and animals with other portions of the Mediterranean Basin (forests and woodlands) and the “Saharan Maghreb”, the desert part with little plant or animal life (steppe, shrubs, sand dunes). Fig 2.4 shows the global land use.

2.2 Agriculture and water resources

Current status agriculture and developments

Agriculture is an importance source of employment for the Maghreb countries. Table 2.2 shows an overview of agricultural area in the region.

Table 2.2 Landuse data Maghreb, area in x1000 ha (source: Aquastat, 2008)

<table>
<thead>
<tr>
<th>Country</th>
<th>Total country area</th>
<th>Agricultural area (FAOSTAT, 2009)</th>
<th>Arable land (temporary crops)</th>
<th>Permanent crops (citrus, olives etc.)</th>
<th>Cultivated area</th>
<th>% Cultivated of total country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>238174</td>
<td>41325</td>
<td>7489</td>
<td>935</td>
<td>8424</td>
<td>3.54</td>
</tr>
</tbody>
</table>
Morocco and Tunisia are both countries with an economy highly dependent on (export) agriculture, whereas Algeria and Libya have an enormous dependency on import of agricultural products. In the past decades an intensification in agriculture took place rather than an expansion of the agricultural area (Fig 2.5).

![Fig 2.5 Cultivated area in hectares since 1990 (source: EUROSTAT. Libya not included)](image)

Table 2.3 shows the value that the agricultural sector added to the Gross Domestic Product (GDP). The GDP value corresponds to forestry, hunting, and fishing, as well as cultivation of crops and livestock production.

<table>
<thead>
<tr>
<th>Country</th>
<th>Value added by agriculture (% of GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2006</td>
</tr>
<tr>
<td>Algeria</td>
<td>8</td>
</tr>
<tr>
<td>Morocco</td>
<td>17</td>
</tr>
<tr>
<td>Tunisia</td>
<td>10</td>
</tr>
<tr>
<td>Libya</td>
<td>2</td>
</tr>
</tbody>
</table>

The value added to GDP has decreased or stagnated in the past years, except for Algeria, where the agricultural sector regained its role in the country’s economic growth.

In the Maghreb countries farmers receive subsidies for basic goods such as wheat, flour, sugar and milk. The subsidy mechanism was introduced originally to reduce poverty, but it gradually became an integrated part of the governments in the region. The subsidies are being argued, amongst others they encourage the overexploitation of aquifers and thus hamper a sustainable use of water resources.

Due to high population growth and in many cases, traditional agricultural practices, the Maghreb is increasingly forced to import goods from abroad. The main imported products are cereals and dairy products. According to the UN Food and Agriculture Organisation (FAO), Maghreb countries imported more than 50% of their grain needs.
in 2010. According to FAO’s recent forecasts, Maghreb countries will remain major food importers in the future, especially of grains, due to the difficult climatic conditions which make food self-sufficiency difficult to achieve.

The Maghreb countries are aware of their vulnerable situation and have put water and food production high on their national agendas. In the past decades, the countries have launched reform programmes and development policies to make the countries more self-sustainable. Until now, the policies have shown its limitations and food dependence in the Maghreb is becoming structural. Some country specific features of the agricultural sector are highlighted below.

### Algeria

The hydrocarbon sector is the main sector in the country. Algeria is member of the Organization of the Petroleum Exporting Countries (OPEC). Oil and gas account for around 97% of Algeria’s export revenue. Algeria and Libya have a higher dependency on import of agricultural products than Morocco and Tunisia. Algeria imports 45% of its food from abroad, mainly cereals and dairy products followed by vegetable oil and sugar (almost $4.8 billion or 17% of its total imports). The Plan National de Développement Agricole’ (PNDA) was established in 2000 to stimulate investments and to promote sustainable agricultural development.

### Morocco

The high mountains of Morocco distinguish it from the other Maghreb countries and play a fundamental role in formulating its climate. Agriculture is the main sector in the country. The sector employs around 44% of the population and contributes up to 16-17% of the GDP. The main agricultural products are cereals, citrus, vegetables and cattle. The major export products are tomatoes, fresh citrus fruits, and potatoes. Land structure is characterized by the predominance of small farms; Three quarters of the farms do not exceed 5 ha. In 2008, Le Plan Vert (Green Morocco Plan) was launched, a national strategy for agricultural development in the region.

### Tunisia

Tunisia has a more diverse economy than other Maghreb countries, with agriculture, industry, mining and tourism as important sectors. The governmental involvement in different sectors is heavy but there is a trend of more private initiatives. Agriculture is responsible for almost 18% of the labour force. Agricultural imports and exports are more or less balanced. Tunisia is characterised by a varied agricultural production. The main agricultural products are olives, olive oil, grain, tomatoes, citrus fruit, and dates. Tunisia is the number two world exporter of olive oil (after the European Union) and the first world exporter of dates (in terms of value). Investments in water saving technologies are subsidised by 40% which led to improved water use efficiencies. To promote private investments in agriculture, the Agence de Promotion des Investissements Agricoles (APIA) has been introduced.

### Libya

The Libyan economy depends primarily upon revenues from the oil sector, which contribute about 95% of export earnings, 25% of GDP. Climatic conditions and poor soils severely limit agricultural output; Libya imports about 75% of its food (Rabobank country report Lybia, 2010). Libya’s primary agricultural water source remains the Great Manmade River Project, a network of pipes that supplies water to the Sahara Desert in Libya. It is the world’s largest irrigation project.
Availability of water resources

The Maghreb countries depend mainly on rainfall and partially on groundwater, while desalination is still at its infancy. The current situation of water resources in the Maghreb has been widely reported: rainfall patterns are highly irregular, demand and consumption are increasing while the most accessible water sources have already been exploited, competition between different user groups is intensifying (e.g. tourism and urban development), erosion hazards and silting of dams, and available resources continue to diminish. The available freshwater resources in the Maghreb are below 1000 m³ per capita, which is the threshold that hydrologists maintain for water scarcity conditions. Incidental water shortages (“water stress”) occur when the per capita freshwater availability drops below 1700 m³/year, while values below 1000 m³ per capita are expected to result in chronic shortages (“water scarcity”) with more severe consequences. The values from Table 2.4 show that the Maghreb countries face a serious threat.

Table 2.4 Available freshwater in m³ per capita per annum (different data sources compared)

<table>
<thead>
<tr>
<th>Country</th>
<th>EMWIS country profiles, NB Libya from other source, m³/inhab/year</th>
<th>FAO estimates 2008 (Aquastat), m³/inhab/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>400 (Algerian ministry of Water Resources, 2008)</td>
<td>339.5</td>
</tr>
<tr>
<td>Morocco</td>
<td>750 (SEEE)</td>
<td>917</td>
</tr>
<tr>
<td>Tunisia</td>
<td>450 (BIRH)</td>
<td>451.9</td>
</tr>
<tr>
<td>Libya</td>
<td>109 (Earthtrends 2003, World Resources Institute)</td>
<td>95.3</td>
</tr>
</tbody>
</table>

Fig. 2.6 illustrates the renewable natural water resources of the Maghreb countries as annual average. The natural renewable water resources refers to the water that is recharged in the hydrological cycle and is the maximum available water for a country within a year.
Groundwater use

Groundwater has been intensively exploited for domestic and irrigation purposes in parts of the Maghreb, which resulted in depleting groundwater tables. Irrigated agriculture in the region relies more and more on groundwater use. Fig 2.7 shows as example the evolution of the water table for the Souss aquifer in Morocco.

![Fig 2.7 Decrease of the level of the aquifer of Souss, example Morocco (Source: Abdelfadel and Driouech, Worldwaterforum5)](image)

The North-Western Sahara Aquifer System

The largest shared aquifer is the North-Western Sahara Aquifer System (Système Aquifère du Sahara Septentrional, SASS), an aquifer shared between Libya, Algeria and Tunisia (Fig 2.8). The aquifer covers an area of over one Million km², of which over 60% are in Algeria, a little less than 10% in Tunisia, and 30% in Libya. According to the Observatory of the Sahara and Sahel (Observatoire du Sahara et du Sahel, OSS), the withdrawals of groundwater from the Algerian and Tunisian parts of the aquifer have risen sharply over the last 50 years. Due to the (semi-) arid conditions in North Africa, the recharge levels of the aquifer are low: an estimated 1 billion m³/year in total, infiltrated at the piedmonts of the Saharan Atlas in Algeria, the Dahar in Tunisia and the Jebel Nafousa in Libya (source: OSS). The three countries sharing the aquifer have been facing the dilemma of securing water for economic development while protecting the water resources from degradation.

![Fig 2.8 The shared North-Western Sahara Aquifer System (Système Aquifère du Sahara Septentrional, SASS) (Source: OSS, http://www.ossonline.org)](image)
The Sahara and Sahel Observatory (OSS) is currently working in partnership with UMA (Arab Maghreb Union) for the establishment of a "Maghreb Observatory for Drought Early Warning (OMAS-UMA) on indicators for drought risk, to be used for national action plans and sub-regional and environmental policies (EMWIS, April 2011).

Rain-fed agriculture and irrigation

In Algeria, Libya, Morocco, and Tunisia, rain-fed agriculture is practiced on more than half of all arable land (AOAD, 2007). The remaining land is irrigated. In the Maghreb, 40% of irrigated land is dedicated to growing cereals (Worldbank, 2009). Fig. 2.9 shows the major irrigation schemes in the Maghreb.

![Fig. 2.9 Areas equipped for irrigation (Source: Siebert et al, 2007)](image)

Water demand agricultural sector

The agricultural sector is the largest consumer of water in the region, and the sector depends significantly on fluctuations of the weather. In Morocco agriculture accounts for the largest share of withdrawals, this share is less in Algeria. Fig 2.10 displays the withdrawals for different sectors as percentage of total withdrawals.

![Fig. 2.10 Water withdrawals as percentage of total use, period 2000-2005 (Source values: AQUASTAT, 2011, FAO).](image)

A steady increase in future water demand is expected; Plan Blue estimates that by 2025, water demand could increase by 25% in the region (Plan Blue, 2007). This is explained by a combination of a growing population, expansion of tourism, migration to urban areas and changes in climate. The increase in water demand for the different Maghreb countries (future projections) is given in the separate country chapters.
Water pricing

Volumetric pricing is applied in irrigation in the Maghreb countries, with different success rates. Water pricing is an incentive to reduce water use, but it is in general a low incentive in the area. Costs are too low to enhance efficiency, and do not recover costs (O&M recovery). For groundwater there is no water pricing, because groundwater use is not controlled/monitored.

Water balance in the Maghreb

To assess the pressure on fresh water resources, the Water Exploitation Index can be used. The index evaluates the water balance as the ratio of total water abstraction per year to the available long-term freshwater resources. An index of over 20% usually indicates water scarcity (European Environment Agency). According to Plan Blue numbers, the water exploitation index is between 38 and 45% for Tunisia, Algeria and Morocco and over 80% for Libya, indicating severely strained natural resources (State of Environment, Plan Blue, 2009).

Water scarcity and climate change

The dependence on rainfall makes the Maghreb countries very vulnerable to climate change. Based on estimates from the UN's latest Intergovernmental Panel on Climate Change (IPCC) assessment, most of the Middle East and North Africa region (MENA) is expected to become hotter and drier. Higher temperatures and reduced precipitation will increase the occurrence of droughts, an effect that is already materializing in the Maghreb (Worldbank A, and UNEP – OSS 2010, draft report). A decrease in precipitation is predicted by more than 90% of climate model simulations by the end of the 21st century for the MENA region (IPCC, 2007, IPCC 4, 2007), which will affect agriculture in the region directly. Awareness has been raised in the Maghreb on the consequences of climate change, which has resulted in the political will to address the issues at regional level (UNEP 2006, http://www.unep.org/dewa/Africa/publications/AEO-2/content/087.htm)

2.3 Agriculture and trade

Europe is the Maghreb's major trading partner in agricultural products. The strategic location, the production potential and the extensive markets of the Maghreb countries makes the EU, among some other social and political reasons, want to increase its cooperation.

Since 1995 the Euro-Mediterranean Partnership (EMP), also referred to as the Barcelona process, forms a central framework for bilateral and regional relations between the EU and its Southern Mediterranean partners. Algeria, Morocco and Tunisia are EMP members; Libya has an observer status. EMP aims mainly to integrate financial and economic cooperation, leading eventually to a free trade zone. So far EMP failed in achieving its ambitious goals. Free trade agreements have been formulated, but the objective of the Barcelona declaration to establish a free trade zone by 2010 is not yet reached.

As a re-launch of the Mediterranean Partnership, the Union for the Mediterranean (UfM) was created in 2008, a multilateral partnership between member states of the European Union and the Mediterranean partner countries from North Africa, the Middle East and the Balkans. The Union for the Mediterranean is the southern regional cooperation branch of the European Neighbourhood Policy (ENP), a policy to create stability, security and prosperity in the Eastern and Southern neighbourhood countries. The EU offers financial assistance to countries within the European Neighbourhood. Algeria, Libya, Morocco, and Tunisia are part of the ENP, a policy developed to strengthen the relations between EU and neighbouring countries.

Despite the partnership agreements, the degree of economic integration among Mediterranean partners remains low. According to the Blue Plan Environment and Development Outlook for the Mediterranean, cooperation
remains insufficient, sustainable development is poorly taken into account and Euro-Mediterranean integration advances unevenly, with limited resources.

Agricultural trade within the Maghreb countries is limited. The Arab Maghreb Union (AMU), or Union du Maghreb Arabe (UMA), was established in 1989 to promote cooperation and economic integration between the countries Morocco, Algeria, Tunisia, Libya, and Mauritania. AMU is seen as a limited effective organization, and progress in regional integration is stagnating as member states continue to rely on overlapping bilateral agreements with each other, limiting intra-Maghreb trade.

2.4 International organisations and datasets

Many international organisations are involved in studies in the water and agricultural sector in the Mediterranean and Maghreb region, sharing valuable information and datasets. Many resources are being put available for agricultural development in the region. Below are the most important organisations and sources which have been consulted for the preparation of the current report.

**Food and Agriculture Organisation FAO**
FAO has a Maghreb office in Tunis, and a satellite office in Algiers.

**Euro-Mediterranean Water Information System EMWIS**
EMWIS is an information system for exchanging information and knowledge in the water sector. EMWIS is an initiative of the Euro-Mediterranean Partnership.

**GWP Med (Global Water Partnership)**
GWP-Med represents the Global Water Partnership in the Mediterranean. It is a platform bringing together competent organisations working regularly on water issues in the region. The main office of GWP-Med is in Athens, with a satellite office in Tunis and one in Lebanon.

**Maghreb Mashreq Alliance for Water (Alliance Maghreb Machrek pour l’Eau, ALMAE)**
ALMAE encourages communication and information exchange in development, water and environment. ALMAE has an office in Casablanca (Morocco).

**Office International de l’Eau (OIEAU), IOWater (International Office for Water)**
The objective of the International Office for Water is to connect public and private partners involved in water resources management and protection.

**The Mediterranean Network of Basin Organisations (MENBO)**
MENBO aims to collaborate with all basin organisations from Mediterranean countries, develop action plans and create awareness related to integrated water management.

**Plan Blue / SIMEDD**

**Observatory of the Sahara and Sahel (OSS)**
OSS was founded in 1992 to improve early warning and monitoring systems for agriculture, food security and drought in Africa. OSS provides access to data on the management of the sepentrional Sahara Aquifer System (SASS) through a Catalog, The GeoAquifer portal.
Public databases:

**EUROSTAT**, the statistical database of the European Union for Southern European Neighbourhood Policy countries

**AQUASTAT and FAOSTAT**
AQUASTAT is FAO’s database on water and agriculture; FAOSTAT is the statistical database of FAO which collects statistics from the countries.

**Worldbank development indicators**
The Worldbank Indicator database shares current and accurate global development data available on water and agriculture, and includes national, regional and global estimates.
3 Algeria

3.1 Water and agriculture

Topography and climate

Algeria can be divided in three regions: the Tell (Atlas mountain chains), the High Plains (steppe plains lying between the Tell and Saharan Atlas ranges) and the Sahara desert (Fig 3.1).

Fig. 3.1 Algeria's topography: Tell region and High plateaus in the north (source: ..)

The climate of Algeria can be typified as semi-arid to arid, with warm winters and hot summers. Climatic variations are large in the country, ranging from a Mediterranean climate in the north to a desert climate in the south. Temperatures in the north range between 5 and 15 degrees in winter, and 25 to 35 degrees Celsius in summer. In the south, temperatures can reach up to 50 degrees Celsius in summer. The rainy season usually starts in October/November and ends in May/June.

Rainfall is very variable in the country, and determines to a large extent the agricultural potential. The average annual rainfall is about 69 mm, but varies from 0 mm in the southern desert up to 1 500 mm in the north-eastern coastal area (source: FAO). The following climatic zones can be distinguished:

- The Tell area and coastal zone (Le Tell), covering around 4% of the country surface area. Mediterranean climate with abundant rainfall. Amounts vary between 600 and 1000 mm annually. There is less rainfall in the western part of the coastal zones and Tell area than in the eastern part. Overall rainfall is sufficient for rainfed agriculture;
- The High plains (les Hauts plateaux) which covers around 9% of the country surface area, which can be divided in 3 regions:
  - Western plains (les Hauts Plateaux de l'Ouest)
  - Central plains (les Hauts Plateaux du Centre)
  - Eastern plains (les Hautes Plaines Est)

The High plains are governed by a continental climate, with rainfall ranging between 400 and 600 mm in the highlands and between 100 and 400 mm in the Steppe;
The Sahara desert (le Sahara au Sud), covering 87% of the country area surface. Here a desert climate dominated by aridity is found, with less than 100 mm of rainfall per year.

In Algeria, around 800 observation posts exist for rainfall monitoring, 240 climatic stations, and 250 stations hydrométrique (ANRH, pers comm, 2011). From these observation data, INSID prepares precipitation maps for Algeria (Fig 3.2).

![Fig 3.2 Precipitation map of Algeria, average for the period 1986-2005 (Source: INSID)](image)

Apart from spatial variability, rainfall also varies considerably on a temporal scale, within a year (Fig 3.3) and has a large inter-annual variability. Such variability has a strong influence on crop production.
Land use and agro-ecological zones

Around 80% of Algeria’s country surface is covered by the Sahara desert, and around 14% is grazing land, the home of Algerian pastoralism. The country has around 8.4 million hectares of farm land (Fig. 3.4).

Agro-ecological zones provide information on climate and soil (edaphic factors), to assess the production potential for the various types of (rainfed) agriculture. The National Institute of Agronomic Research INRAA defines the agro-ecological zones for Algeria as (Overview of irrigation in Algeria and Research prospects, INRAA 2011):
The humid, sub-humid and semi-arid zones of the North are oriented towards diversified agricultural products as cereals, vegetables, fruits and of semi-intensive livestock (especially milk and meat). In these zones (Tell area and the High Plains), rainfall determines to a large extent the agricultural potential.

- The intermediate zone (steppe), semi-arid to arid, oriented towards livestock, especially sheep farming due to its large and extensive grazing areas;
- The arid to hyper-arid Saharan desert where the only agricultural activities are based on irrigated agriculture or crops storied and exploitation of the palm trees.

**Agriculture and crops**

The agricultural sector in Algeria contributes to about 12 percent of the GDP (2009 value, Worldbank), which makes it the second largest GDP contributor in the country. Currently around 8.4 million hectares are cultivated (temporary and permanent crops), which is only 3.5 percent of the total country surface (Aquastat, 2008). A large part of the country is desert area and not suitable for crop production.

More than half of the arable land in Algeria depends on rainfall. In other parts, full or partial irrigation is required since precipitation is either not sufficient or poorly distributed in time, not matching crop requirements. At the moment one third of the farms is owned by the state, and the remaining two-third is owned by private farmers. Farms are generally small, and there is not a strong tradition of cooperation between farmers.

### Factsheet agriculture Algeria

<table>
<thead>
<tr>
<th>Rural population</th>
<th>11,868,000 in 2010 (34% of total population) (source: UN, The 2007 Revision Population Database)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main agricultural crops</td>
<td>Cereals (wheat, barley, oats), grapes, dates, olives, citrus, fruits, sheep and cattle.</td>
</tr>
<tr>
<td>Arable land (area used for agriculture)</td>
<td>8,424,760 ha (temporary &amp; permanent crops), source EUROSTAT value 2008; Of which 7,489,000 ha is temporary crops, source: 2008 Worldbank indicators and FAO</td>
</tr>
<tr>
<td>Available agricultural land</td>
<td>41,204,102 ha, corresp. 17.3% of total area (source: 2008 Worldbank indicators and FAO)</td>
</tr>
<tr>
<td>Irrigated area</td>
<td>Grand Perimeters Irrigué: 219,000 ha; Petite et Moyenne Hydraulique: 850,000 ha (source: Ministry Water Resources, 2008)</td>
</tr>
<tr>
<td>Food imports (cereals, milk whole dried, meat, coffee, sugar)</td>
<td>Cereal import 6.3 m tonnes in 2008; Wheat 4.7 M tonnes of wheat in 2009/10 (July/June marketing year), source: FAO GIEWS.</td>
</tr>
<tr>
<td>Food exports (dates, ..)</td>
<td>Food exports are minimal.</td>
</tr>
</tbody>
</table>

**Land use and crop types**

The most suitable areas for crop production are the northern areas with sufficient rainfall: The fertile coastal plains of the Tell region and the rain inducing High plains. This crop growing area (including pastures) is restricted to about a hundred kilometres inland. Further inland, more drought tolerant agriculture is practiced such as tree crops (Fig. 3.5).
Cereals are mostly grown in the northern region as this give highest production potential (Table 3.1).

Table 3.1 Suitable zones for rainfed wheat in Algeria (Source: Adapted from FAO wheat database)

<table>
<thead>
<tr>
<th>Climate</th>
<th>Where</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-tropical Mediterranean</td>
<td>Coastal belt.</td>
<td>High potential for wheat. Average daily T between 9 °C to 15 °C. Annual rainfall between 600 - 800 mm, most during winter.</td>
</tr>
<tr>
<td>Continental Mediterranean climate</td>
<td>Eastern Algerian mountains and plateau between coastal mountains and Saharan Atlas.</td>
<td>Medium potential for wheat. Average daily T in winter vary between 8 °C and 16 °C. Average annual rainfall of 400 mm - 600 mm.</td>
</tr>
<tr>
<td>Continental semi-arid Mediterranean climate</td>
<td>Southern side of the plateau, adjoining and extending into the Saharan Atlas</td>
<td>Low potential for wheat. Winters are cold, with mean daily temperatures of 7 °C to 14 °C, but sufficiently mild for wheat. Rainfall ranges between 250 mm - 400 mm. This is too small and too erratic, region is marginally suitable for rainfed wheat</td>
</tr>
</tbody>
</table>
Substantial reforms are on-going in the Algerian agricultural sector, which increased the contribution to GDP considerably in recent years. However, the sector is unable to meet the food demand of the country, and Algeria is one of the largest importers of agricultural products in the world. Around 45 percent of the food is imported (source: wiki), mostly cereals and dairy (milk powder). The government has taken measures to reduce cereal imports, such as the extension of cultivated area for cereals and an improved irrigation policy.

Fig. 3.6 Main crops (harvested area) in the different regions (Source FAO Agromaps, 2010).

Characteristics of Algeria’s main crops are described below.

**Box. Characteristics of Algeria’s main crops**

**Cereals**

The northern parts of Algeria are the main cereal growing lands (Fig. 3.6), the coastal areas and rain-inducing high plateaus with fertile soils, a relative mild climate and sufficient rainfall for cereals (300-400 mm/year). Wheat is the most produced cereal crop in Algeria. FAO estimates that 6.9 million ha of land would be suitable for rainfed wheat. More than 3 million hectares are used for the cultivation of cereal grains (Worldbank reports 3,2 million ha in 2009). According to official estimates, grain production in 2011 will be around 4.68 million tonnes, which is similar to 2010 (FAO/GIEWS). Cereals are rainfed, with minimal irrigation. Yields depend largely upon frequency and amount of rainfall during the growing season. Cereals have a long planting window from October to January (planting date depends on onset rain), and harvest in June/July.

Fig. - LEFT: crop calendar cereals (FAO/GIEWS) - RIGHT: Cereal yield in kg / ha, 1996 – 2009 (values from Worldbank – Worldbank indicators)

The new agricultural strategy aims to expand cereal (mainly wheat) by improved yields and an increase of harvested area. At the moment Algeria is one of the largest importers of cereals, mainly (durum) wheat. In 2010, wheat imports totalled 5.232 million tonnes, and total cereal imports 7.8 million tonnes (FAO/GIEWS). The policies launched by the state to reduce imports and boost cereal production have successfully reduced imports but grain self-sufficiency is not reached yet. However the potential for a further expansion of rainfed wheat area is clearly there!
Potatoes
Potato is the second crop after wheat in Algeria, and the consumer market for potatoes is growing. The total potato growing area is estimated at 90,000 ha. In 2010 around 3.2 million tonnes were produced, which equals around 65% of the country needs (Algérie Soir). Potatoes are grown in the coastal region with mild climatic conditions, in the plateaus and in higher, mountainous rain-induced areas (Fig 4.6). New cultivars and fertilization have improved yields. Potatoes are grown between April and September and require between 500-700 mm of water.

Date palms
Dates are the most important agricultural export product of Algeria. Dates are one of the few crops that can be grown in deserts as they survive long droughts. Dates are grown in oases in the Saharan Wilayas (prefectures). The most productive Wilayas are Biskra, El Oued, Ghardaia, Adrar and Ouargla. Some 72,000 hectares are cultivated with palm trees. Ouled Said (Adrar province) is a network of oases in southwestern Algeria and covers an area of around 25,000 hectares. It is a centre of date production in northern Africa. The implementation of the state’s policy PNDA resulted in a large expansion of the area cover by date palm trees. Water requirements for date palms in Algeria are estimated at 15,000 - 35,000 m³/ha. Date palms need water of acceptable water quality.

Olive trees
Olive production is expanding in Algeria, and currently around 300,000 ha of olive orchards are grown. Olives are mainly grown for national consumption, and 80% is used for oil production, and 20% for table consumption (olive de table). The majority of the trees are grown on mountainous, marginal lands in the north where rainfall varies between 400-800 mm/year and in the western plains with 300-400 mm yearly rainfall. Most of the olives are rainfed, around 75% of the total area.
Dairy

Algerians consume a relative high amount of milk and dairy products. A significant increase in milk production happened under the PNDA. The dairy sector production is now meeting 40% of local needs, based on a per capita annual consumption of 110 liters. The remaining amount is imported, partly from the Netherlands. The government has a policy for fixed (controlled) prices for pasteurized fluid milk.

Water resources

Algeria is Africa’s second most water scarce country, after Libya. There are no large rivers in Algeria. The Chéliff River in the coastal plain is the only significant stream, providing some water for irrigation. Water is unevenly spread over the country. While most regions suffer from water shortage, yearly floods can also occur after heavy rains. A real challenge in managing Algeria’s water resources is the large fluctuations in supply from year to year and in regions. Large efforts have been undertaken by the state to mobilize water resources by building dams.

The problems related to water can be summarized as follows (INRAA pers comm, 2011):
- Scarcity and uneven distribution;
- Low mobilization;
- Low-productivity;
- Insufficient management.

Water availability

The National Agency for Water Resources (Agence nationale des ressources hydrauliques, ANRH) in Algiers provides the data on Algeria’s water resources. The agency monitors how much water is available from rainfall and from groundwater, and generates maps on water quality.

Surface water

There are five hydrographical basins in Algeria (Fig 3.7) which cover a total number of 19 watersheds (bassins versants). Table 3.2 and Fig 3.8 show the water availability for these basins.

<table>
<thead>
<tr>
<th>Hydrographical basin</th>
<th>Watersheds (bassins versants)</th>
<th>Available water in km3/year</th>
<th>Dams (barrages en exploitation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chéliff</td>
<td>ALGEROIS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oranie Chott Chergui</td>
<td>HCDNA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sahara</td>
<td>SOUMMAM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constantinois</td>
<td>SEYBOUSSE MELLEGUE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 3.7 Hydrographical basins (source: Ministry of water Resources, http://www.mre.gov.dz)

Table 3.2 Water availability in hydrographical basins (source: Ministry of water Resources, http://www.mre.gov.dz)
<table>
<thead>
<tr>
<th>Hydrographical Basin</th>
<th>Surface Water Availability per Basin (%)</th>
<th>Source: Values MWR, 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oranie Chott-Chergui</td>
<td>1.0</td>
<td>update requested</td>
</tr>
<tr>
<td>Cheliff - Zahrez</td>
<td>1.8</td>
<td>15</td>
</tr>
<tr>
<td>Algerois - Hodna – Soummam</td>
<td>4.4</td>
<td>12</td>
</tr>
<tr>
<td>Constantinois - Seybouse – Mellegue</td>
<td>4.5</td>
<td>16</td>
</tr>
<tr>
<td>Sud (Sahara)</td>
<td>0.6</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>12.3</td>
<td></td>
</tr>
</tbody>
</table>

Fig.3.8 Surface water availability per hydrographical basin as share of total (source: Values MWR, 2004)

**Groundwater**

Two types of groundwater resources are distinguished:

- The Northern groundwater zone, which are renewable resources, with a capacity estimated at 2 billion m³/year. This groundwater layer is fed by rainfall, which has an irregular distribution.
- The Southern groundwater zone, which are non-renewable (fossil) resources, with an estimated capacity of 5 billion m³/year without risk of hydrodynamic disturbance. These resources are exploited by deep wells and man-made water harvesting structures called foggaras. The non-renewable water resources are represented by two large aquifers, being the Complex Terminal and the Continental Intercalaire.

Irrigation in the Algerian Sahara is dominated by the use of (non-renewable) groundwater. Groundwater use for irrigation has increased considerably in e.g. the Saharan wilayas of Biskra, El Oued, Ghardaia and Adrar, which are very productive date cultivation areas. Irrigation has been intensively developed by the government as part of the PNDA. The increased groundwater use, in combination with the fact that the more unshallow aquifers in the south are often saline, represents a double challenge to agricultural development in the area.
The use of groundwater can hardly be controlled. The permission to dig wells for groundwater exploitation is controlled, however the use of groundwater is not controlled and it is free (Pers comm DHA, 2011). A series of deep wells are constructed by the Government, but farmers often also dig their own wells, often low-cost shallow wells, where groundwater is saline. This has led to environmental degradation in some areas.

For the shared North-Western Sahara Aquifer System (SASS), which is mostly fossil water, there is an agreement for use between Tunisia, Algeria, Libya (SASS agreement).

Below the water profile of Algeria is summarized, quantifying the water availability and water demand.

<table>
<thead>
<tr>
<th>Water profile Algeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional water resources</td>
</tr>
<tr>
<td>Definition</td>
</tr>
</tbody>
</table>
| Estimated water potential (billion m3/year) | Approximately 17 of which:
- 10 surface resources;
- 7 groundwater resources (both renewable and non renewable) |
Of the groundwater resources:
- 2 in the north (fed by rain)
- 5 in the south, of which only 0.8 are renewable. | Ministry of Water Resources, 2011
| Renewable water resource, long-term average (billion m3/year) | Total renewable water resources 11.67
Internal renewable 11.25
Of which:
Surface water 9.76
Groundwater 1.49
External renewable 0.42 (= surface inflow from Tunisia 0.16 and from Morocco 0.23, groundwater entering country 0.03) | AQUASTAT, 2008 |
| Long-term average annual precipitation in mm | 89 mm / year | AQUASTAT |
| Water per capita in m3/inhab./year | 400 m3/year | EMWIS / Algerian ministry of Water Resources, 2008 |

| Water demand |
Total freshwater withdrawal 6.161

Agricultural 62%
Municipal 24%
Industrial 14%

Water supply infrastructure

<table>
<thead>
<tr>
<th>Dam capacity</th>
<th>Current mobilization of water:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface resources: Dams: 2.8 billions of m³ (68 dams)</td>
</tr>
<tr>
<td></td>
<td>Underground water resources: 3.5 billions of m³ (forages–well–sources)</td>
</tr>
<tr>
<td></td>
<td>Total is 6.3 billions of m³.</td>
</tr>
</tbody>
</table>

Ministry of Water Resources

Pressure on water resources (water balance)

<table>
<thead>
<tr>
<th>Withdrawals of percentage of annual renewable water resources</th>
<th>53%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aquastat</td>
</tr>
</tbody>
</table>

Future prospects

Algeria, with its arid and semi-arid climate, is highly vulnerable to climate change with desertification as a major concern. Overall, temperature and evaporative demand is expected to increase for Algeria. The change in future rainfall is however more debated. A small decrease is expected up to 2025, but exact values are unknown. Knowledge about climate change is restricted by a lack of information in general for the region. A recent study by Laborde et al. (2010) however has shown that even a small decrease in rainfall will have a disproportional large reduction in water availability (runoff) for (northern) Algeria.

Water quality

According to UNECA, 44% of Algeria’s water resources would be of good quality, 44% of satisfactory quality and 12% of poor quality (Source: UNECA, 2005). Especially in the north of Algeria, water quality is deteriorating.

The Agence Nationale des Ressources Hydraulique (ANHR) monitors the water quality. A number of 130 stations are used to measure groundwater quality both in surface water and groundwater, based on 30 parameters (chemical and biological). The water quality maps published by the ANRH show that significant sections of rivers in the basins of Tafna, Macta, Cheliff and Soummam Seybousse are now polluted.
Mobilization of water

To satisfy the growing water demand, Algeria’s policies are directed towards an increase in water supply by increasing the number of water infrastructures. There are a number of 68 dams operational now in the country, mostly in the north. The dams supply around 65% of the water that is used for agriculture (Source: DHA, 2011, pers comm).

The National Agency of Dams and Transfers (Agence Nationale des Barrages, ANBT) is in charge of the construction and maintenance of dams. Silting of dams is becoming a problem; At the moment, in Algeria reservoirs have lost one quarter of the original capacity already due to silting (Plan Blue 2007).

Water transfer

To mitigate water shortages in different part of the country, several large water transfer projects have been realized. One of the mega projects is the south-south transfer “Water Mega Project In-Saleh-Tamanrasset”, operational since March 2011. It supplies water from In Salah Albien to the regions in the far south of Algeria (Tamnarasset) over a distance of 750 km. The project provides up to 100 million m3/year, with water coming from underground sources.

The use of non-conventional water resources

The use of non-conventional water resources such as treated wastewater and desalinization is not widespread yet in Algeria. The country launched major desalination projects on the Mediterranean shore (14 stations in 2010, production of 2.39 million m3/day); (EMWIS country profile). Desalinized water is estimated at 140 millions m3/year, and treated waste water account to 270 m3 (MWR, 2008).

Algeria owns the largest desalinization unit in Africa. More than 10 desalinization plants are operational, and the intention is to have a number of 43 plants running by 2019. The Hamm site is the largest converter of seawater into drinking water (200,000 m3/day) in Algeria.

The lack of an integrated approach in water management

Until now the water supply side has received a lot of attention in the country. The Ministry of water resources put a large focus on mobilizing water resources to increase water supply, by constructing new dams and installing new wells. The environment has not been high on the political agenda of the Ministry. Now, with the commitment to reach the Millennium Goals and the land and water degradation the country is facing, the need for a sustainable development is acknowledged. The demand side, i.e. the reduction of water use, is now increasingly receiving attention. This process has been started by implementing more efficient irrigation methods, the use of treated waste water in agriculture, and more progressive water pricing.

Developments in irrigation

Irrigation is of fundamental importance for Algeria. The irrigated area occupies approximately 10% of the cultivated land, but contributes to around 40% of the total agricultural production. The National Office of irrigation and Drainage (ONID), part of the Ministry of Water Resources, is in charge of the management, exploitation and maintenance of the hydraulic facilities and irrigation networks. Irrigation is mainly applied for strategic crops (in order of area irrigated): Vegetables, fruit trees, palm trees, fodder, and cereals.
Regarding water pricing, the water price of surface water is low and in many cases not paid.

(Pictures market watermelons, irrigated by sprinkler, Blida, 29 June 2011)

The irrigated area has increased considerably in the past decade. The total irrigated area in 2000 was estimated at 350,000 ha, increased to 830,000 ha in the year 2008, and is currently (2011) estimated at around 1 million hectare. The objective for irrigation per crop type in 2011 was set at (DDZASA, Ministry of Agriculture, 2011, pers comm):

- Cereals: 300,000 ha
- Potato: 100,000 ha
- Vegetables: 200,000 ha
- Fruits: 480,000 ha
- Palm trees (dates) 20 million trees (not expressed in hectares).

The irrigated area is divided in major irrigated areas and small / medium irrigation:

Box. Irrigation areas (Source values: DHA, 2011, pers comm)

| Large scale irrigation (GPI, Grand Perimeters Irrigué) with schemes > 5000 ha. |
| Water is supplied by dams. At the moment around 227,000 ha is currently equipped, out of a potential of 430,000 ha. An area of 60,000 ha is actually irrigated, which is 25% of the area equipped (DHA, 2011, pers comm). Main irrigated areas are in the wilayas of Biskra, Chlef, Blida, Algiers, Mascara, Tlemcen and Relizane. Major crops irrigated are fruits and vegetables. The Ministry of Water Resources will restore/rehabilitate an area of 70,000 ha (from the 227,000) and is planning to have 270,000 ha functioning in 2014; |
| Small and medium irrigation (PMH, Petite et Moyenne Hydraulique) with schemes < 200 ha. |
| Water is supplied by small dams or groundwater. Numbers are reported between 850,000 and 1 million ha for the area actually irrigated (DHA, 2011, pers comm). For small irrigation areas, the Ministry of Agriculture is also involved. |

Irrigation methods

According to the Irrigation Department (Direction de l’Hydraulique Agricole, DHA, pers comm), 70% of irrigation is based on traditional techniques (surface irrigation), and 30% of the area is irrigated using modern irrigation methods (drip, sprinklers).
Spate irrigation is also applied successfully in Algeria and is one of the major examples in the Maghreb (DDZASA, Ministry of Agriculture, 2011, pers comm). It is a technique that uses water from sudden floods to fill storage canals. This technique is unique to semi-arid regions.

In Algeria desertification is putting extreme stress on irrigated agriculture due to the fast rate of soil and water salinization, resulting in the drastic reduction of arable land with productive agricultural potential. This phenomenon is most notable in the Western part of the country where major irrigation schemes are located. Out of a total area of 140,000 hectares in this part of Algeria, 30% consists of very saline soils (cited. Source: FAO/IAEA Programm).

Irrigation programmes

Algeria has introduced a number of new irrigation projects to improve the country’s food security. Two large actions plans have been released by the government to boost agricultural production, with a focus on expansion of irrigated area and introducing water saving techniques:

The 2010-2014 Action Plan. In 2010 a programme was launched (programme economie de l’eau), to extend the irrigation area, apply water saving and to increase food security. The ambition of the agricultural sector is to increase irrigated areas by the year 2014 upto 1.4 M ha.
For the period 2015-2020, another ambitious goal is set: An irrigated area of 500,000 ha in total will be realised, of which 280,000 ha is located in the northern region and 220,000 ha in the Sahara region. (Source: elwatan.com, 02/02/2011, http://tinyurl.com/6c24ckg).

**Summary of challenges in the agricultural sector of Algeria**

The main bottlenecks in water and agriculture in Algeria can be summarised as:

- Water supply in Algeria is irregular and insufficient. A large part of the country is not suitable for agriculture. New challenges must be met to boost agricultural production and develop (foreign) markets.
- Salinization and problems in water quality are becoming a problem in Algeria.
- A real integrated approach in water management is lacking at the Ministry level, as well as the tools and models to support this. There is a lack of spatial and temporal information on both the resources available and the demand for water. It is recognised that inadequate expertise at various levels is a core problem.
- Agriculture could make a better use of rainfall in Algeria. There is a need for development of techniques associated with rainfed agriculture, adaptation of irrigation systems to changing weather conditions, supplementary irrigation, conservation of soil water, etc.

**3.2 National and regional plans, policies**

For long Algeria has given priority to (heavy) industry, but the agricultural sector has been put back on the agenda. Reforms in agriculture have been undertaken by the Government to improve the performance and reduce dependency on imports. One of the most important reforms are the National Plan of Agricultural Development (Plan National de Développement Agricole, PNDA) in 2000, and the water pricing policy of 2005.

**National Plan of Agricultural Development (Plan National de Développement Agricole, PNDA)**
Two development plans have been launched: The National Plan of Agricultural Development (PNDA, launched in 2000) and its successor, the National Plan of Agricultural and Rural Development (PNDAR, launched in 2004). The objective of the development plan is to increase the amount of cultivated area by more than 1,000,000 hectares, to create 2,000,000 new jobs and to achieve a growth rate averaging between 8% and 10% from 2010 onwards. PNDAR aims to reduce imports (mainly cereals and dairy) and provide food security by diversifying farm production.

Two funding instruments have been made available to promote and modernize the sector: the National Agriculture Investment Development Fund (to support the agriculture investment) and the National Fund for the Regulation of Agriculture Production (to support the agriculture production).

These plans led to a remarkable progress in the agricultural sector. Since the PNDA was launched in 2000, an increase of 500,000 ha irrigated area has been realised and more than 1,000,000 jobs have been generated.

Plan for the development of food-processing industries in 2014 (Plan national d'appui aux industries agroalimentaires, PNDIAA)

Many opportunities exist in the food processing sector and in conservation technologies (e.g. canning, refrigeration) in Algeria. The Government has initiated a plan for development of food-processing industries (PNDIAA). The plan aims to improve coherence in national production in the private sector, reduce imports and stimulate export. An amount of 380 billion Algerian Dinars DZD (1 DZD equals around 0.0134 USD, rate March 2012) is made available to achieve a growth of 60% in the food processing sector in 2014. This requires a closer cooperation between the food processing sector and the agricultural sector.
4 Morocco

4.1 Water and agriculture

Topography and climate

Morocco’s geography is characterized by mountains: The Rif, High Atlas, Middle Atlas, and Anti-Atlas (Fig. 4.1). The mountainous areas with bordering plateaus distinguish Morocco from its neighboring countries. The Rif and the Atlas play a fundamental role in the country’s climate as they serve as natural barrier against the extreme conditions of the Sahara. The coastal plains are fertile and rich in precipitation.

![Topography of Morocco](source: own creation from SRTM data)

Morocco is relatively more humid than other Maghreb countries. Morocco's climate is a moderate one: Mediterranean, with hot, dry summers and cold, wet winters. Rains are concentrated in two periods: one in autumn and one in winter (Source: SEEE 2011). Inland, the temperatures can rise to extreme levels.

The main rivers in the country are the Moulouya which runs into the Mediterranean, and the Sebou which runs into the Atlantic. The longest river in Morocco is the Oum Er-Rbia, with a length of 555 km.
Morocco is characterized by irregular rainfall patterns, with a large inter-annual variation. The average annual rainfall is over 1000 mm in the mountainous areas of the north (Rif, Mediterranean coast) and less than 300 mm in the basins of the Moulouya Tensift, Souss-Massa, the areas south of the Atlas and the Saharan zone (Fig. 4.2). The unequal temporal rainfall distribution results in irregular water flows, which led to the construction of large dams and reservoirs for water storage in dry periods.

**Land use and agro ecological zones**

In general, three climatic zones can be distinguished in Morocco that determine agricultural suitability:

- The coastal plains and plateaus: Mild climate with sufficient rain in northern areas, however decreasing when moving south. Fertile grounds, main growing agricultural areas for large scale cereal production and vegetables.
- The Rif and Atlas mountain highlands: Mild climate, colder temperatures and high rainfall zones. Diversified agriculture with pasture land (crop and livestock production), forest.
- Southern part of the country / desert: Virtually no rain, and harsh climate conditions. Oases areas with e.g. date production.

A first mapping of agro-ecological zones in Morocco was done in the year 2000 for the preparation of the *Atlas de l’Agriculture Marocain* (CGDA, 2009), a study to better adapt agricultural practices and policies to natural conditions, the diversity of farmers and to the heterogeneity of production potential. In this study, a set of nine agro-ecological units was identified (Fig 4.3a).
To analyse the major agricultural production systems in Morocco, the nine zones were reduced (merged) to a number of five major agro-systems (Fig 4.3b):

1. Large irrigation schemes (Perimètres de Grande Hydraulique), the large schemes are essentially those of Rharb and Loukkos;
2. Mountains (Montagnes), with agricultural and pastoral activities;
3. Pre-Saharan and Saharan zones (_regions predesertiques et desertiques_);
4. Semi-arid / arid zone (Regions arides et subarides), these include the Lower Moulouya, Tadla, Haouz, Doukkala Abda, Souss Massa;
5. Plains and plateaus with rainfall above 400 mm (Bour favourable des plaines et plateaux).
Fig 4.3b Main agro-systems in Morocco (Les grands agro systèmes du Maroc, CGDA 2009)

For the five main agro systems, the total area (hectares) and the number of exploitations was analysed (Table 4.1). The table shows a clear dominance of the semi-arid agro-system (44% of the arable land, or "Surface Agricole Utile", SAU), followed by the "bour favorable" (plains and plateaus with rainfall above 400 mm) with 26.1% of the arable land. From the table it can be concluded that agriculture in Morocco is dominated by agro-systems in the potential limited or difficult, semi arid mountains, which occupy almost two-thirds of the arable land of the country. Areas with potential favorable conditions ('bour favorable') and large-scale irrigation occupy one third of the national arable land.

Table 4.1. Total area and number of exploiter for the five agro-systems (CGDA, 2009)

<table>
<thead>
<tr>
<th>Agro-systèmes</th>
<th>SAU en 1000 ha</th>
<th>% Total Maroc</th>
<th>Nombre exploitations 1000</th>
<th>% Total Maroc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montagnes</td>
<td>1664</td>
<td>19.0</td>
<td>437.4</td>
<td>30.6</td>
</tr>
<tr>
<td>Plaines et collines en bour favorable</td>
<td>2282</td>
<td>26.1</td>
<td>287.7</td>
<td>20.1</td>
</tr>
<tr>
<td>Plaines et plateaux en semi aride/arde</td>
<td>3843 (dont steppes 508)</td>
<td>44.0</td>
<td>520.3 (dont steppes 54.3)</td>
<td>38.4</td>
</tr>
<tr>
<td>Grande Irrigation</td>
<td>707.4</td>
<td>8.1</td>
<td>100.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Zones sahariennes &amp; pré-sahariennes</td>
<td>236</td>
<td>2.7</td>
<td>85.4</td>
<td>5.9</td>
</tr>
<tr>
<td>Ensemble du Maroc</td>
<td>8732</td>
<td>100</td>
<td>1431.6</td>
<td>100</td>
</tr>
</tbody>
</table>

Agriculture and crops

Agriculture is the main source of income in Morocco and contributes to around 17% of the GDP (CIA Factbook, estimated value for 2010). Since independence, priority in development was given to the agricultural sector. Almost half of the national labour force is working in the agricultural sector, which is the highest of the Maghreb countries. Around 80% of the 14 million rural inhabitants depend on revenues from the agricultural sector (ADA, 2009). According to FAO an area of around 9 million hectares is cultivated (temporary and permanent crops), which amounts to 20% of the country's surface.

Agriculture in Morocco is dominated by small scale farming. Around 70% of the Moroccan farmers has less than 5 hectares of land available for crop production (source: ADA, 2009). The government’s strategy in agricultural development is to keep people in the regions, for this reason agriculture is developed throughout the whole country.

Agriculture in Morocco is predominantly rainfed (irrigation de bour). Rainfall is unevenly distributed over the country. Water flows in rivers are irregular and captured by large dams for irrigation. According to the Ministry of Agriculture and Fisheries (Ministère de l’Agriculture et de la Pêche Maritime, MADRPM), around 15% of the cultivated area is irrigated which amounts to 1.4 million hectares. The irrigated sector contributes to an average of up to 99% for sugar production, 82% for vegetables, 100% for citrus fruits, 75% forage and 75% for milk (MADRPM 2011).

Both traditional, subsistence agriculture and modern agriculture are seen in Morocco. Today’s agriculture in Morocco can be characterized as follows:

- Modern private sector, irrigated, producing vegetables and fruits, aimed at export;
• Irrigated perimeters from large dams, producing for local market;
• Small scale rainfed agriculture, north western part of Morocco, south and eastern part. Mainly cereal production and pulses.

The agricultural sector is suffering from increased droughts, and the Ministry of Water Resources and Environment (Secretariat d'Etat Charge De L'eau et de l'Environnement, SEEE) reports a significant reduction in rainfall and flows in recent decades. The overexploitation of groundwater for agriculture is a serious problem and has resulted in an alarming situation of ground water (El Gueddarl et Arrifi, 2009).

Morocco produces 60% of the cereals needs itself, and imports 40% of the requirements (source: Personal communication DIAEA). The increased droughts in past years resulted in the need to import more grains. The Centre for Environment and Development for the Arab Region and Europe (CEDARE) state that Morocco and Egypt have the highest share of net cereal imports – an alarming fact given the growing population (CEDARE, 2009).

In 2008 Morocco’s Green Plan (le Maroc Vert) was introduced, a new policy for the modernization of the agricultural sector. An estimated yearly amount of 1 billion US dollars is made available to implement modern irrigation technologies, provide training, develop export of horticultural products and attract foreign investors. As Moroccan agriculture is dominated by cereal production, the Green Morocco Plan provides an ambitious program of conversion of land to more rewarding uses, such as fruit growing pasture and plantations (Source: MADRPM, 2010). The horticultural sector is now growing rapidly in Morocco, mainly in the north.

### Factsheet agriculture Morocco

<table>
<thead>
<tr>
<th>Rural population</th>
<th>14,007,000 in 2010 (43.3% of total population) (source: UN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main agricultural crops</td>
<td>Agriculture is dominated by cereals (barley, wheat) which cover 65% of the arable land. Other main crops are citrus and vegetables.</td>
</tr>
<tr>
<td>Arable land (area used for agriculture)</td>
<td>8,7 million hectares (source: MADRPM 2010)</td>
</tr>
<tr>
<td>(temporary &amp; permanent crops)</td>
<td>8,980,600 ha (source: EUROSTAT, 2008), 20 % of the country surface</td>
</tr>
<tr>
<td>Available agricultural land (temporary &amp; permanent crops, pastures)</td>
<td>30,055,000 ha (source: FAOSTAT, 2009) corresponding 67% of the total area</td>
</tr>
<tr>
<td>Irrigated area</td>
<td>1,458 million ha (source: SEEE, 2011), corresponding 15% of cultivated area</td>
</tr>
<tr>
<td>Food imports</td>
<td>Alimentary products imported, 2010 value: 34,8 milliards DH. Main imports: cereals, huiles alimentaires, sugar and milk products. (Source: MADRPM 2010)</td>
</tr>
<tr>
<td>Food exports</td>
<td>Major export crops are vegetables and (citrus) fruits. Upcoming for export: Strawberries and artichoke. Agricultural products exported value in 2010: 15,8 milliards DH (source: MADRPM 2010)</td>
</tr>
</tbody>
</table>
Agricultural crops and location

Morocco’s agriculture is dominated by cereals, mainly wheat and barley. These are mostly grown under rainfed conditions, between September and June. Cereals are cultivated throughout the country, but with higher production in the coastal basins along the Atlantic coast: Gharb, Doukkala, and Haouz (ADA, 2009), see also Fig 4.5.

Citrus crops are the second crop after cereals (Fig 4.4). The major citrus production area of Morocco is the Souss Massa valley (Agadir), a leading export region for oranges and clementines. The region accounts for nearly half of Morocco’s citrus production. This area continues to face critical water shortages which hamper the chance of expanding citrus area planted in the future. In contrast, the Gharb region in the northern part of Morocco (Kenitra/Sidi Kacem region) appears to have high potential for production growth. Expansion of citrus production in the Gharb area has been constrained by aging orchards, limited number of citrus varieties planted, and the lack of new investment. Water scarcity in the Souss region, and the appeal of the export markets encouraged many leading citrus producers to reconsider the Gharb area as an alternative region to expand citrus production. (source: USDA Foreign Agricultural Service, 2009).
A summary of Morocco’s main crops are described below.

**Box. Characteristics Morocco’s main crops**

**Cereals**

Cereals are the most important agricultural products in Morocco, and cover 65% of the arable land (MADR, 2010). The most occurring cereals are wheat (*blé dur* and *blé tendre*) and barley (*orge*). Cereals are cultivated throughout the country, but with higher production in the coastal basins of the north of Morocco: Gharb, Doukkala, and Haouz. Wheat is mainly produced in irrigated zones while barley is mostly grown under rainfed conditions in non-irrigated or mountainous zones. (ADA, 2009).

![Production of three main cereal crops (x 1000 tons), source: MADR 2010](image)

Cereal production fluctuates widely over the years, influenced by rainfall variability. Production levels are generally poor compared to other countries in the Mediterranean Basin (ADA, 2009). Morocco is not self-subsistent in cereals and imports around 40% of it's demand (personal communication DIAEA, 2011).

The Green Morocco plan advocates a sustainable restructuring of the cereal sector that focuses on a production-based strategy (ADA 2009). A "productive heart" will be developed focusing on the principal cereal basins:

- Irrigated perimeter: Haouz, Doukkala-Adba, Gharb...
- Favourable (rainfed), non-irrigated perimeter: Saisse, Chaouia, Zaer-Zemmour

**Citrus (agrumes)**

Morocco has a long tradition of citrus production. The traditional Clementine, and the Navel and Valencia-late (*Maroc-late*) oranges are the most common citrus products. An average of 500 thousand tons are being...
exported to Europe yearly, which is about 40% of the national citrus production (MADRPM, 2010). The Souss valley is the largest citrus production area, and provides about half of Morocco’s total citrus production.

Fig (pie) regional distribution of citrus (source MADRPM, presentation 2011, Morocco water.ppt)

Drought conditions have now become a problem in the valley. The Morocco Green Plan provides an increase in financial support for new citrus plantations in alternative regions.

Graph: Export of citrus products (source: MADRPM 2010)

Olives
The area under olive cultivation is currently around 750,000 ha (MADRPM, 2010, value 2009/2010). Olive production used to be fragmented in Morocco with low average production levels. However the Green Morocco Plan has boosted the olive oil sector by extending the area of olive trees and intensification of existing olive groves. Production levels have increased from 900,000 tons in 2007/2008 to 1,500,000 tons in 2009/2010 (MADRPM, 2010).

Graph: Evolution of tomato exports (source: CGDA, 2010)

Vegetables and pulses
Vegetables are after cereal production and fruits the most important sector in terms of production. The most common vegetables produced are tomatoes, peppers, pulses and potatoes. A major vegetable greenhouse growing area is the Souss Massa valley. This region provides 99% of the tomato exports. Pulses (légumineuses) such as beans and chickpeas, cover an area of around 373,000 ha (CGDA, 2010). Another successful vegetable crop are Moroccan capers, a Mediterranean culinary shrub product. Morocco is one of the world’s top producer and the first export country in the world, producing around 14.000 tons (personal communication Morocco Economic Competitiveness Program, MEC).
Water resources

Water availability

Surface water

Morocco is characterized by a large (inter-) annual variability of rainfall. Of the approximately 29 billion m$^3$ of useful rain that Morocco receives, the annual average potential exploitable amount is estimated at values ranging between 19 to 22 billion m$^3$ per year (19 billion m$^3$ per year is reported by SEEE 2010; 20 billion m$^3$ per year is reported by MADRPM 2010; 22 billion m$^3$ per year is reported by ABHS 2011). From this amount, around 75-80% becomes available from surface water and 20-25% from groundwater.

The existing legal water framework for water resources is mainly governed by the Water Code ("Le Code des Eaux") approved in 1995. This law enabled a modernization of surface water regulation in the country, and involves a decentralization where the river basin agencies are responsible to plan and manage water resources within their catchments. Also water quality monitoring and enforcement is entrusted to the basin agencies.

Morocco is divided in nine river basins (bassin versant), see Fig. 4.6. The nine river basin agencies (Agence Du Bassin Hydraulique, ABH) undertake the management of water resources under the supervision of the Secretariat d'Etat charge de l'Eau et de l'Environnement (SEEE). Morocco has the longest experience in the MENA region with basin agencies, established legally by its 1995 water law (Worldbank 2007; Mena development report).
The Basin Agencies cooperate with irrigation offices called Offices Régionaux de Mise en Valeur Agricole (ORMVA) at the level of large irrigated districts, which operate under the supervision of the Ministère de l’Agriculture et de la Pêche Maritime (MADRPM). ORMVA is not dealing with groundwater. For areas outside the ORMVA domain, the Basin Agencies collaborate with the Agriculture Provincial Directorates (DPA) (source: EMWIS/ SEMIDE country profile Morocco). Small farmers outside the ORMA domains are represented by the Association des Usager de l’Eau Agricole (AEUA). These are local associations representing small farms in an area of around 300,000 hectares (personal communication CGDA 2011).

There is a strong spatial heterogeneity in water availability: More than half of the available water resources are concentrated in the northern basins and the Sebou basin (SEEE, 2010). Fig 4.7 shows the renewable water resources for the basins, in shares for surface water and groundwater.

![Graph showing renewable water resources per basin in Mm3/year](source: own representation, data from El Gueddarl et Arrifi, 2009 / UNESCO)

The hydrological year 2009-2010 was characterized by favorable rainfall conditions. These rains generated significant water supply but also large floods, some of which have never been recorded in the history of hydrological observations (source: SEEE 2011b).

**Groundwater**

The mobilization effort of groundwater, undertaken since 1961, has led to a large exploitation of groundwater. SEEE is in charge of authorization on the use of groundwater. The “Contract de Nap” is an agreement between stakeholders and involves regulatory measures about the use of groundwater. To limit and control its use, groundwater is part of the National Water Strategy (personal communication MEC). The Ministries MADRPM and SEEE work together to limit the use of groundwater and to have its use officially registered, and unauthorized use of groundwater will be reported (personal communication DIAEA).

The amount of groundwater that potentially can be mobilized (potentiel des ressources en eau mobilisables) is estimated at 4 billion m3 (El Gueddari and Arrifi - UNESCO 2009, and SEEE 2011a). The volume of groundwater resources actually extracted is estimated at 2.87 billion m3 per year in 2010 (source: SEEE 2011a), which is excessive and exceeds the potential in some areas (see below). Other sources report mobilised volumes of 3.5 billion m3 (El Gueddari et Arrifi, 2009) and 3.166 billion m3 (Aquastat, 2000 value).
Table 4.2 Groundwater resources by river basin source (Bzioui, 2005, http://www.uneca.org/na/Events/Attachment16.pdf [original source DRPE, 2004])

<table>
<thead>
<tr>
<th>Water shades</th>
<th>Potential of exploitable water (Mm³/yr)</th>
<th>Actual extraction (Mm³)</th>
<th>Remaining possibility of extraction (Mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loudiahs, Tangier and Côte d'Azur</td>
<td>226</td>
<td>140</td>
<td>86</td>
</tr>
<tr>
<td>Monastir</td>
<td>779</td>
<td>270</td>
<td>509</td>
</tr>
<tr>
<td>Sebou</td>
<td>453</td>
<td>380</td>
<td>73</td>
</tr>
<tr>
<td>Oum Er Rbia</td>
<td>326</td>
<td>500*</td>
<td></td>
</tr>
<tr>
<td>Bou Regreg</td>
<td>126</td>
<td>510*</td>
<td></td>
</tr>
<tr>
<td>Tensift</td>
<td>458</td>
<td>640*</td>
<td></td>
</tr>
<tr>
<td>Souss-Massa</td>
<td>240</td>
<td>230</td>
<td>532</td>
</tr>
<tr>
<td>Souss-atlasiques</td>
<td>762</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Safara</td>
<td>16</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Diffus flow</td>
<td>614</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>4,000</td>
<td>2,670</td>
<td>1,200</td>
</tr>
</tbody>
</table>

Source DRPE (2004)

Table 4.2 lists the potential exploitable water and the actual mobilized groundwater (Bzioui, 2005, original source DRPE, 2004). Groundwater resources are being over-exploited in certain regions, i.e. in the basins of Oum Er Rbia, Tensift, Souss-Massa, and partly in Sebou. Irrigation is the predominant water user in these regions. Examples of depleted water tables resulting from over-exploitation are shown in Figs 4.8a and 4.8b, which is the combined effect of a reduced supply (rainfall) and an increased extraction of groundwater. In some regions there is still potential to mobilize groundwater, e.g. in the basin of Moulouya, in the northeastern part of Morocco.

Fig. 4.8a. Depletion of water tables in Morocco (source: El Gueddar l and Arrifi, 2009 / UNESCO).

Fig. 4.8b. Overexploitation of groundwater in Saiss, Sebou basin (source: Agence du Bassin Hydraulique du Sebou, 2011)

Water profile Morocco

<table>
<thead>
<tr>
<th>Conventional water resources</th>
<th>Definition</th>
<th>Value</th>
<th>Information source(s)</th>
</tr>
</thead>
</table>

47
| **Estimated water potential - exploitable**  
(billion m³/year) | 19  
(“mobilisables dans conditions techniques et économiques acceptables”)  
of which:  
- 15 surface resources;  
(18 from Sebou, 16 MADR, 13,5 SEEE 2011b, 15.7 AQS)  
- 4 groundwater resources, of which  
2.87 is being used at the moment  
(SEEE 2011a) | SEEE, 2011a |
|-------------------|---------------------------------------------------------------|-----------------|
| **Renewable water resources**  
(billion m³/year) | 20.7 | Plan Blue 2009 |
| **Long-term average annual precipitation in mm** | 346 mm / year | AQUASTAT |
| **Water per capita in m³/inhab./ year** | 730 m³/inhab/year | SEEE, 2010 |

**Water demand**

| **Withdrawals per sector (km³)** | Agricultural 11.01  
Municipal 1.628  
Industrial 0.4766  
Total freshwater withdrawal 12.6 | AQUASTAT |

| **Water supply infrastructure** | Total storage capacity 17.2 billion m³ (128 large dams in operation) | SEEE, 2011a |

**Pressure on water resources (water balance)**

| **Withdrawals as percentage of annual renewable water resources** | 43 %  
(withdrawal / total renewable) | AQUASTAT |
Effects of climate change to water availability

According to SEEE, reduced rainfall over the past thirty years resulted in a 20% reduction of surface water availability at the dam sites (SEEE, 2011). SEEE reports that most of the river basins will suffer from water deficit by 2030, and the accumulated deficit is estimated at 2.4 billion m³ per year (SEEE 2010).

Climate change has more pronounced effects in arid and semi-arid regions such as Morocco. A recent modeling study for the Worldbank on hydrological response to climate change shows that considerable changes in precipitation, temperature and reference evapotranspiration are projected for the MENA region. Climate change will affect the water resources from two sides: An overall decrease in precipitation in combination with a higher evaporative demand will reduce the water availability considerably. The study concludes that Morocco is one of the countries that can be expected to experience severe water shortages. For Morocco a change from 2010 to 2050 in renewable water resources is calculated at -33% decrease (Immerzeel et al. 2011).

Water quality: A trend of degradation
SEEE reports a trend of degradation in Morocco’s surface water quality. Recent examination of the overall quality of surface water by river basin shows that the level of river Souss and Bourregreg, the quality of rivers is generally good, while the basins of Sebou (pollution) and Loukkos record as many areas of poor quality (SEEE website). In the Agadir region (Souss Massa basin) salinity problems occur (personal communication CGDA).

The majority of underground water sources are of poor quality due to high salinity and nitrate concentrations. The Sebou basin (representing 29% of the water resources) is most heavily polluted, mainly from industrial disposal and agricultural drainage. Nitrates and phosphorus are present as well as pesticide residues (METAP, year unknown). The factors responsible for degradation of groundwater are the strong mineralization of these waters and the presence of high levels of nitrates. The ground water is highly mineralized groundwater in Berrechid, Chauxia coastal Kert, Garab, Bouareg, Beni Amir and Tafilalt. In addition, high levels of nitrates were recorded in layers of Fez-Meknes, Tadla and Abda-Doukkala Angad (SEEE 2011a).

Mobilization of water

Building of dams and water transfers

Because of the irregular distribution of rainfall in time and space, Morocco’s policies have been directed towards water storage since the mid-1980s. Large dams, reservoirs and water transfers have been constructed to develop water resources and ensure economic and social development. Currently, a number of 128 dams have been constructed with a total capacity of 17.2 Mm³ (Fig. 4.9). In addition, a network of 1100 km of water transfer systems has been realized, to transfer a total amount of 210 m³/s (source: SEEE 2011).
An increased mobilization of conventional water resources is part of the Stratégie Nationale du Secteur de l'Eau (National water strategy), which contains the following elements (SEEE 2010):

- Completion of 50 new, large dams (mobilization of additional 1.7 billion m3) by 2030;
- Around 1000 small dams for local development by 2030;
- North-South transfer to support the socioeconomic development of the basins Bouregreg, Oum Er Rbia and Tensift: First phase from 400 Mm3/year Sebou, second phase from 400 Mm3/year Loukkos-Laou;
- Making a better use of rainfall: Conducting pilot projects to capture rainwater.

Sedimentation of dams is a problem in Morocco, which reduces water storage capacity by about 50 million m3 per year (Worldbank 2007, making the most of scarcity).

**Developments in irrigation**

Irrigated agriculture is a crucial part of Morocco’s national and regional economy. Significant investments over the past four decades in terms of hydraulic infrastructure and storage facilities have boosted the development of irrigation. Irrigated agriculture occupies around 15% of the cultivated area (1.458 million hectares in 2011 reported by SEEE) and accounts for 75% of agricultural exports (MADRPM, 2011). Table 4.3 shows the distribution of irrigated areas over the different basins.

**Table 4.3 Irrigation basin (source: Aquastat)**
<table>
<thead>
<tr>
<th>Basin</th>
<th>Irrigated area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bouregreg et côtes atlantiques</td>
<td>28 331</td>
</tr>
<tr>
<td>Loukkos et côtes méditerranéennes</td>
<td>63 600</td>
</tr>
<tr>
<td>Moulouya</td>
<td>155 451</td>
</tr>
<tr>
<td>Oum Rbiaâ et côtes Jadida Safi</td>
<td>478 448</td>
</tr>
<tr>
<td>Sebou</td>
<td>333 156</td>
</tr>
<tr>
<td>Souss-Massa et côtes Agadir - Tiznit</td>
<td>140 996</td>
</tr>
<tr>
<td>Sud-Atlasiques</td>
<td>125 243</td>
</tr>
<tr>
<td>Tensift et côt. Safi - Essaouira</td>
<td>158 935</td>
</tr>
</tbody>
</table>

The irrigation sector can be divided in three types (Table 4.4)

- **Grande Hydraulique**: *La grande hydraulique* is the biggest agricultural development since independence. It covers large schemes covering an area of 682,600 hectares, operated by ORMVAS;
- **Petit et Moyenne Hydraulique (PMH)**: Traditional small and medium-scale irrigation covering 334,130 hectares owned and operated by local communities;
- **Privately developed schemes**.

Traditional irrigation (gravity irrigation, "robta") is the most common irrigation method (80% of the irrigation area), which is considered inefficient. Faced with the alarming situation of depletion of groundwater, the state has taken incentives to encourage the use of more efficient, water-saving techniques. A program is being implemented to equip an additional 550,000 ha of irrigation by the year 2020 (PNEEI, see below). Subsidies are provided for the equipment of drip irrigation systems and technical assistance to farmers for the design and construction of their irrigation systems.
Table 4.4 Irrigation types in Morocco, in hectares (source: l’Etat de ressources en Eau au Maghreb, 2009)

<table>
<thead>
<tr>
<th>Irrigation type</th>
<th>Gravity</th>
<th>Sprinkler</th>
<th>Drip</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grande Hydraulique</td>
<td>533887</td>
<td>113808</td>
<td>34905</td>
<td>682600</td>
</tr>
<tr>
<td>Petit et Moyenne Hydraulique (PMH)</td>
<td>327230</td>
<td>6900</td>
<td>0</td>
<td>334130</td>
</tr>
<tr>
<td>Irrigation Privée</td>
<td>306157</td>
<td>17038</td>
<td>118235</td>
<td>441430</td>
</tr>
<tr>
<td>Total</td>
<td>1167274</td>
<td>137746</td>
<td>153140</td>
<td>1458160</td>
</tr>
</tbody>
</table>

The major irrigation perimeters are shown in Fig 4.10. The irrigation perimeters of Haouz, Tadla, Doukkala, and Gharb are the largest in Morocco.

Fig. 4.10 Main irrigation perimeters in Morocco (source: MADR, "presentation Morocco water" IAV)

Summary of challenges in the agricultural sector of Morocco

The Agency for Agricultural Development (ADA) summarizes the bottlenecks in the development of national agriculture as follows (ADA, 2009):

- Limited water resources: Poor and irregular rainfall and inefficient irrigation systems;
- Traditional agriculture with relatively large losses of water;
- Insufficient investments and poorly developed agro-industrial infrastructure;
- Insufficient organization of the agricultural sector;
- Parcelling of property: The excessive parceling of property is a major constraint in the development of our agriculture, where 70% of farms are smaller than 5 hectares. In addition to small farm sizes, the legal system concerning property is complex.
- Dominance of low value crops: Cereal crops occupy 75% of arable area and represent only 10 to 15% of agricultural revenues.

4.2 National and regional plans, policies

Morocco is in the process of implementing reforms to modernize its economy and to be better connected to other regions in the world. Sustainable agricultural development has been given high priority, and reforms have been set in by the “Le Plan Vert”. The national policy is to keep people in their regions, and therefore all regions need to be developed (personal communication DIAEA 2011).
Le Plan Vert

Le Plan Vert (Green Morocco Plan) constitutes a road map for agricultural development in the region that is supported by both the central government and public authorities. This agricultural development strategy has the following goals:
- The improvement of revenues;
- The contribution to food safety and security;
- The integration of the agricultural sector into national and international markets;
- The conservation of the agricultural environment and the securing of potential production.

The Green Morocco Plan aims at enhancing the value of agricultural potential, incorporating the modern sector and that of the traditional and food-crop sector. To do so, the Green Morocco Plan rests upon two pillars:
- Pillar I aims at the accelerated development of a modern form of agriculture, characterized by high value added products and by its adaptation to the market economy;
- Pillar II aims at upgrading the situation of smaller stakeholders and at fighting against rural poverty through the improvement of farming income.

The Green Morocco Plan has adopted an innovative model: aggregation. This model allows for the surpassing of constraints linked to the parcelling of property while insuring that aggregated farms have access to modern production technologies, to financing and to the market (ADA, 2009). Action plans have been developed for each of the 16 administrative regions, which resulted in 16 Region Agricultural Plans.

Extension of irrigation area: the Gharb region

An area of 140,640 ha will be equipped for irrigation up to the year 2016, as part of the “Programme d'extension de l'irrigation a l'aval des barrages” (DIAEA, 2010b). This programme on dam construction to mobilise water for irrigation is part of the Green Morocco Plan. The extension will take place mainly in the Gharb region (Al Wahda dam). In addition to an extension of irrigation area, more efficient irrigation techniques such as drip irrigation (irriguée en localisée) are promoted.

Promotion of efficient irrigation methods: Programme National d'Economie d'Eau en Irrigation (PNEEI)

The Programme National d'Economie d'Eau en Irrigation (PNEEI, National Program for Saving Water in Irrigation) is part of the Green Morocco Plan, and aims to mitigate the effects of scarcity of water resources and improve efficiency of water use in irrigation. This program, with a total value of 37 billion Dh, aims at a conversion of surface irrigation and sprinkler to drip irrigation for an area of 550,000 hectares in 2020 (source: MADRPM, 2010). This concerns both collective and individual farms (personal communication CGDA 2011):
- 220,000 hectares collective farmers, of which an area of 20,000 hectares of small farms (small parcels) will be grouped into areas of 6-14 ha;
- 330,000 hectares individual farmers, to whom the state provides subsidies up to 70% to convert to drip irrigation.

PNEEI is designed around five main components (DIAEA, 2010):
- The collective modernization (including the upgrading of common infrastructure in irrigation systems to facilitate the conversion to irrigation water saving to the plot).
- The upgrades to the individual farm level.
- The agricultural use.
- Strengthening of technical support through the development of a local council in the design of drip irrigation systems and support to improve productivity.
- Accompanying measures.

PNEEI is not only based on the conversion to more efficient irrigation techniques, but also on the improvement of the full process of agricultural development and recovery of production, from choice of crops, improved cultivation techniques, organization, marketing and agribusiness. The main expected effects of PNEEI are water savings of 30 to 50% (510 Mm3/year in zones of grande hydraulique and about 500 Mm3/year in areas of private irrigation), increase in domestic agricultural production, increase in farmer's income, protection of water resources and the environment by controlling leaching of fertilizer and reducing groundwater abstraction (El Gueddarl and Arrifi, 2009).

**Fonds de Développement Agricole (FDA)**

The Agricultural Development Fund (FDA) was initiated in 1986 to promote private investment in agriculture and to provide subsidies to better exploit the national agricultural potential. As such, the FDA has been a key instrument for implementing government policy in the agricultural sector and improving farmers' income (ADA, 2009). The ambitious strategy which has been developed for the agricultural sector imposed a substantial revision of the agricultural incentive system in order to enhance its role in the expansion of agricultural investments, and contribute effectively to achieving the Green Morocco Plan. The new system of agricultural subsidies, in force since March 2010, helped to introduce new aid in accordance with the commitments made in the programs under contracts signed between the state and inter-key production sectors and the strengthening of aid allocated to some items, but also an encouragement and a strong incentive to aggregation.
5 Tunisia

5.1 Water and agriculture

Topography and climate

Tunisia is the smallest of the Maghreb countries. The landscape in Tunisia is diverse, with mountainous regions in the north west, coastal plains along the Mediterranean Sea and the Sahara desert in the south (Fig 5.1). The country can roughly be divided in three topographic regions:

- North: the plain of the Medjerda river, the only permanent river in Tunisia, is surrounded by the Kroumirie mountains and Mogods hills (collines des Mogods) on one side and the Tunisian dorsal on the other side. To the east, the Gulf of Tunis and the Cap Bon peninsula are the historical centres of the country;
- Centre: the western part consists of hills and mountains and fertile valleys where the eastern part is a series of flat plains (the Sahel);
- South: to the west, the great depression of Chott el Djerid and its palm groves are the border of the Sahara desert. To the east, it is separated from the coast line by the Matmata hills.

Tunisia’s climate changes rapidly from north to south. The predominant climate in Tunisia is Mediterranean in the north and Saharan in the south. Mainly three climate regions can be distinguished: (sub) humid in the north, semi-arid to arid in the north west and centre, and (hyper) arid in the south (Fig 5.2).

Rainfall in Tunisia is characterized by a high spatiotemporal variability. It ranges from 1500 mm in the far north and rarely exceeds 50 mm in the extreme south (Besbes et al, 2008). The estimated rainfall in Tunisia amounts to 36,000 Mm3/year, corresponding to an average rainfall height of 220 mm/year (Chahed et al, 2010). About 80% of the rainfall is concentrated between October and March. The annual potential evapotranspiration ranges from 1200 mm in the north to 1800 mm in the south (source: Aquastat Tunisia profile). The high variation in rainfall makes storage of freshwater a primary necessity in Tunisia.
Landuse and agro-ecological zones

FAO distinguishes four agro-ecological zones in Tunisia (Table 5.1). The suitable rainfall conditions (quantity) in the north provides good opportunities for rainfed agriculture of mainly cereals and fodder crops.

Table 5.1 Agro-ecological zones Tunisia (source: FAO country profile Tunisia)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Annual rainfall (mm)</th>
<th>Agriculture and land use</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>500 &lt;Rain &lt;1000</td>
<td>Natural forest, maquis and grazing areas; possibility of rainfed crops: annual crops and horticulture</td>
</tr>
<tr>
<td>Dorsal</td>
<td>400 &lt;Rain &lt;500</td>
<td>Forest, maquis and rangelands but fragile; possibility of cropping but with risky annual crops and tree crops adapted to edaphic and topographic conditions</td>
</tr>
<tr>
<td>Centre</td>
<td>200 &lt;Rain &lt;400</td>
<td>Forest and maquis very fragile in favourable edaphic and topographic conditions. Rangelands are fragile. Possibility of cropping but with risky annual crops and tree crops.</td>
</tr>
<tr>
<td>South</td>
<td>Rain &lt; 200</td>
<td>Very fragile steppe in favourable edaphic and topographic sites. Rangelands very easily degraded. Rainfed agriculture is locally possible with good management of run-off.</td>
</tr>
</tbody>
</table>

Agriculture and crops

Tunisia’s economy is more diverse than in the other Maghreb countries. The role of agriculture in economic growth is important, although proportionally, the agricultural GDP tends to decline slowly (Chaheb, 2010). Although its share of GDP is gradually decreasing, agriculture still plays an important role in the economy, accounting for 10.6% of GDP (2010 value reported by CIA factbook).

Until now agricultural policy in Tunisia is focused on food self-sufficiency (Lebdi, 2009). Tunisia is self-sufficient in most food products except cereals and fodder, that are mostly rainfed and its yield depend on weather.
conditions. The current volume of cereal production does not meet the national demand, and the shortage of grains is being imported.

The arable land is estimated at 5 million hectares, divided into the following uses (ONAGRI, 2011):
- Arboriculture: 2 million hectares (of which 1.6 million hectares of olive trees),
- Field Crops: 2 million hectares (of which 1.6 million hectares of cereals)
- Fallow: 0.7 million ha,
- Various crops: 0.3 million hectares.

Tunisia is one of the world’s top exporters of olive oil. Initiatives are ongoing to increase the value of olive oil (“branding”). Other export products are dades, tomatoes, melon and potatoes.

The largest part of agriculture in Tunisia is rainfed and subject to weather fluctuations, making it more difficult to meet the food demands, especially for strategic crops for the country’s economy such as cereals, fodder and olive (Lebdi, 2009). In an average hydrological year, it represents 65% of the national production and 80% of the agricultural exports (Besbes et al 2010).

Rainfed agriculture in Tunisia covers nearly 4.5 million hectares, mainly used for cereal crops and olive trees. These two dominant rain-fed cropping systems occupy more than two thirds of the rain-fed agricultural lands on various soils and climatic conditions. Rainfall in Tunisia presents a very important contrast between the northern and southern regions and rain-fed agriculture has accommodated with these contrasting rainfall conditions. The Northern regions, where rainfall exceeds 500 mm/year, represent the major areas of cereal farming, while the centre of the country, where rainfall is much lower and more variable, is typically devoted to olive tree plantation. Both are mostly grown under rain-fed conditions and their productions are submitted to strong interannual variations (Chahed et al., 2011). Statistical data show that the production of grains vary according to rainfall and are very variable from one year to another. As stated by Lebdi (Lebdi 2009), this deficiency of rain-fed agriculture is particularly felt in areas of the country where agricultural diversification is absent. Livestock is therefore important in combination with crops, which gives some security.

While rainfed agriculture is concentrated in the north (cereals, olives), irrigation takes place in the middle part and the south. Irrigated agriculture is an important part of the national strategy for growth and stabilization of local agricultural production, and the area is estimated at 410,000 ha, which is only 8% of the agricultural area. This 8% produces 35% of the total agricultural value (pers comm Hamdane, 2011). Irrigated crops are:
- 1/3 horticulture such as tomates (*maraichage*)
- 1/3 fruits (*abricozen*, *pommier* etc.)
- 1/3 cereals

In general, Tunisian agriculture is characterised by small farm plots. Around 85% of the farmers produce only for their own consumption (source: USDA document). Around 53% of the farmers use less than 5 hectares (Worldbank, 2006). Most farms are privately owned, although State farms (located near Tunis) are still important. State farms are small but very productive.

**Factsheet agriculture Tunisia**

<table>
<thead>
<tr>
<th>Rural population</th>
<th>3,489,000 in 2010 (source: UN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main agricultural crops</td>
<td>Cereals, fruit (citrus, olive, dates), vegetables (tomatoes, potatoes).</td>
</tr>
<tr>
<td>Arable land (area used for agriculture)</td>
<td>4,962,210 ha (EUROSTAT 2008)</td>
</tr>
</tbody>
</table>
Crop types

The area along the Mediterranean coast and the western region receive the most rainfall, and are the most productive areas.

Agricultural production is dominated by livestock, followed by the tree (olives, dates, citrus), vegetables and cereals (ONAGRI, 2011), see Fig 5.3. Tunisia's cereals are mainly wheat and barley, similar as in Morocco and Algeria. Wheat is more dominant in the north (Fig. 5.4) while barley (better suited for dryness) occurs more in the central-southern part.
Box. Characteristics Tunisia’s main crops
(main source: Portail de l’Agriculture Tunisienne)

Olives, dates and other fruit trees (Arboricole)
Arboriculture is the mainstay of Tunisia’s agricultural sector. Fruit trees are spread over an area of over 2.2 million hectares, of which most (84%) is cultivated in olive and almond trees in parts of Central and South. Given the possibilities for export, fruit trees have become a major component in all agricultural development projects, and the government is increasingly promoting the planting of fruit trees.

Olive trees cover around 1.7 million ha. By region, the olive oil production areas are located in the north 14%, 67% in the center and 19% in the south. The table olive trees are located for 74% north, 20.3% and 5.7% in the center to the south. The average production of olives is about 1 million tons, equivalent to 200 thousand tons of oil. Olive oil is exported as bulk product, mainly to Italy, Spain and the United States. Initiatives have started to export high value, processed (packaged) olive oil (Fonds de Promotion de l’Huile d’Olives Conditionnée).

Date palm trees cover 40 000 hectares in the south of Tunisia. Tunisia has a large variety of dates, the most cultivated varieties are Deglet Nour and Allig, covering 67% and 11% of planted area. The average production of dates is in the order of 130 000 tonnes.
Vegetables
Tunisia’s Mediterranean climate with mild winter and sunny springs are suitable for most vegetables. Vegetable crops cover an area of 150,000 ha, mostly tomato (25,000 ha), potato (23,000 ha), melon, pepper and onions.

Cereals
Cereal production depends largely on rainfall in Tunisia and is grown on 1.35 million hectares (source: LNW in Noord Afrika, 2009), mainly wheat and millet. Agricultural production has been boosted by national policies, to ensure food security. Tunisia worked on modernizing parts of the cereal production. Irrigated wheat growing areas are being increased, to around 120,000 ha currently.

Water resources

The Ministère de l’Agriculture, des Ressources Hydrauliques et de la Pêche is in charge of water resources (mobilization and use) and agricultural production as well as urban water supply (Société Nationale d’Exploitation and Distribution Water: SONEDE) and rural supply (Directorate General of Agricultural Engineering and Water Exploitation: DG / GREE).

Large public investments have been made in the agricultural water sector. Tunisia is fairly advanced in water resources planning and its scarce water resources are almost entirely mobilised (Besbes et al, 2010). Due to the high natural irregularity in water availability, the national strategy focused on infrastructure for water mobilization through large dams and water transfers.

Water availability

The potential conventional water resources are estimated at 4.8 million m$^3$ per year, of which 2.7 Mm$^3$ is surface water and 2.1 Mm$^3$ is groundwater (sources: ONAGRI Agricultural portal Tunisia; Hamza, 2006; Gaaloul, year?, Besbes et al, 2008). Table 5.2 summarises the water resources.

Table 5.2 Water resources in Tunisia for surface and groundwater in km$^3$/year (sources of values in brackets)

<table>
<thead>
<tr>
<th></th>
<th>Potential (conventional) water resources 10$^9$ m$^3$ per year</th>
<th>Exploitable (“mobilizable”) 10$^9$ m$^3$ per year</th>
<th>Mobilised (year 2008) 10$^9$ m$^3$ per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water</td>
<td>2.7</td>
<td>2.1 (Hamza 2006, Besbes et al 2010)</td>
<td>2.1</td>
</tr>
</tbody>
</table>
Groundwater

The exploitable groundwater resources of Tunisia are estimated at 2,150 Mm3/yr (Hamza, 2006), out of which 745 Mm3 come from shallow aquifers and 1380 Mm3 from deep aquifers. From the deep aquifers, 650 Mm3 are non-renewable from deep aquifers in the South (INAT personal comm).

The north of Tunisia is distinguished by its richness in shallow groundwater (coastal plains of north-east). The north preserves 55% of the shallow ground water resources, the central part 30%, whereas the south contains only 15%. Regarding deep aquifers, the south contains 58% of resources, the centre contains 24%, whereas the north contains only 18%.

The South of Tunisia is dominated by the Saharan platform where large aquifers extend over hundreds of thousands of km2. Tunisia shares these reserves with Algeria and Libya, which are only partially usable and weakly renewable (Chahed et al, 2010).

Currently the shallow water reserves are overexploited. Plan blue reports overexploitation rates of 120 to 130% in the aquifers of the eastern coast of Cap Bon, and the Sahel of Sousse and of Sfax (Plan Blue, 2001). Besbes et al (2008) report a number of 108% for the year 2005.

<table>
<thead>
<tr>
<th>Hydrological region</th>
<th>Available surface water</th>
<th>Potential of the country</th>
</tr>
</thead>
<tbody>
<tr>
<td>North (far North: watersheds Wadis Barbara, Zouara; North: basins of the Medjerda, Cape Bon)</td>
<td>2,200 Mm3/yr</td>
<td>81%</td>
</tr>
<tr>
<td>Centre (watersheds Nebhana, Merguellil, Zeroud and the Sahel)</td>
<td>320 Mm3/yr</td>
<td>11%</td>
</tr>
<tr>
<td>Hyper-arid South</td>
<td>180 Mm3/yr</td>
<td>8%</td>
</tr>
<tr>
<td>Total</td>
<td>2,700 Mm3/yr</td>
<td>81%</td>
</tr>
</tbody>
</table>

Surface water

The northern basins in Tunisia provide the largest contribution of surface water resources of the country. The major basins in the North are the Medjerda Basin, in the extreme North, and the Oued Miliane. Most dams are constructed on these oueds, as the high variation in rainfall makes storage of water a necessity. The northern basins account for 81% of the surface water potential.

Basins in the central and southern part provide low and irregular surface water supplies. The centre part and the southern part of the country account for respectively 11% and 8% of the water (Table 5.3). In the centre, three dams have been built on the Zeroud, Merguellil and Nebhana Oueds.

<table>
<thead>
<tr>
<th>Hydrological region</th>
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</thead>
<tbody>
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</tr>
<tr>
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</tr>
<tr>
<td>Total</td>
<td>2,700 Mm3/yr</td>
<td>81%</td>
</tr>
</tbody>
</table>
Aquifer recharge
To address the aquifer overexploitation, Tunisia has focused on aquifer recharge initiatives since 1992 (AfDB 2011), e.g. in the Kairouan aquifer. Further, water is transferred from the Mejerda valley to the coastal area of Ras El jebel (Cap Bon irrigation areas) and injected into the aquifer. Recharge is also carried out with treated waste water in the Korba region. The total amount recharged between (1992-2009) is estimated at 650 million m³, amounting to 35 million m³ per year (Lebdi, year..., powerpoint).

Water profile Tunisia

<table>
<thead>
<tr>
<th>Conventional water resources</th>
<th>Definition</th>
<th>Value</th>
<th>Information source(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable water resources (billion m³/year)</td>
<td>Total renewable water 4.186 (2.700 surface water, 1.486 groundwater)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources mobilised (billion m³/year)</td>
<td>Resources mobilized: 4.1 billion m³ (2008) - Surface water: 2.1 billion m³ through 29 large dams, 222 hillside dams and 810 small lakes, - groundwater 2 billion m³ through 4700 and 138 miles deep drilling shallow wells.</td>
<td></td>
<td>ONAGRI; Chahed et al 2010; Besbes et al 2010</td>
</tr>
<tr>
<td>Long-term average annual precipitation in mm</td>
<td>36,000Mm³/yr, corresponding to an average rainfall height of 220 mm/yr</td>
<td></td>
<td>Chahed et al 2010</td>
</tr>
<tr>
<td>Water per capita in m³/inhab./year</td>
<td>450</td>
<td></td>
<td>Hamza, 2006</td>
</tr>
</tbody>
</table>

Water demand

<table>
<thead>
<tr>
<th>Withdrawals per sector (billion m³/year)</th>
<th>Agriculture 2.14 (irrigation) Domestic 0.38 Industrial 0.14 Tourism 0.03 Total 2.69</th>
<th>Ministry of Agriculture and Water Resources, 2010 (Gruhne woche)</th>
</tr>
</thead>
</table>
**Water supply infrastructure**

| Dam capacity | 27 large dams (height above 15 m), 200 small dams and 800 small lakes (2008). This infrastructure can mobilize 1,800Mm3/yr. | Chahed et al, 2010 |

**Water balance**

It is expected that after 2020, an imbalance will appear between the conventional water resources regularized and the total water demand of the country (Lebi, 2009; PAPS EAU 2010). By 2030, demand is likely to exceed the conventional resources available.

**Climate change**

The most likely consequences for Tunisia seem to be a reduction in rainfall and an increase in the frequency of droughts (Besbes et al 2010). However, the extent and the accuracy remain imprecise.

**Water quality**

Salinity is a problem in Tunisia. Less than half of the country’s resources meet health and agronomic standards and have less than 1.5 g/l of salinity levels. Around 74 percent of the surface water is within this “suitable” category, together with 20 percent of the deep groundwater, and 8.4 percent of the shallow groundwater has less than 1.5 g/l of salinity (Gaaloul, year?, whitepaper).

The quality of surface water varies greatly by region. Surface water has a generally low salinity (with the exception of the tributaries entering the Medjerda river from the south). Groundwater is badly affected with 84 % of all groundwater resources having salinity levels of more than 1.5 g/l and 30 % of the shallow aquifers more than 4.0 g/l (Gaaloul, 2008).

Groundwater resources in coastal aquifers (Cap Bon, Sahel, and Gulf of Gabes) and in the chotts (Nefzaoua and Jerid) suffer from salinization problems due to seawater or saline water intrusion, resulting from over exploitation. As a result, the quality of these aquifers has deteriorated considerably (Gaaloul, 2008).

**Non conventional water resources**

Tunisia has a long experience of generating non-conventional water to supplement its scarce natural supplies: Reuse of treated wastewater, desalination of salt and brackish water, and artificial recharge of aquifers. Since the 1970s, Tunisia has been formally reusing treated wastewater in agriculture and now has one of the world’s highest rates of reuse (Gaaloul, whitepaper). In 2010, non-conventional water, made up essentially of treated wastewater, amounted to 225 million m3 (Gaaloul 2008). Desalination is practiced particularly in the South East.
(Gabes, Zarzis, Djerba ...) to meet the drinking water needs of large cities and tourist areas. The daily capacity of installed desalination in Tunisia is estimated at 90,000 m³ (Hamdane, year unknown, L’irrigation en Tunisie).

**Developments in irrigation**

Irrigation started after 1959, by creating water storage infrastructure and dams. In the early days or irrigation, the irrigated area amounted to 60,000 ha, mainly in oasis. Currently the irrigated area is estimated at 410,000 ha, representing 8% of the total cultivated area. This 8% produces 35% of the total agricultural value (INAT pers comm) and contributes to 25% of agricultural products exports (Chahed et al 2010). The irrigation sector accounts for the largest water demand (80% of exploitable resources). The irrigated crops are (partly for export):

- 1/3 horticulture such as tomatoes, peppers, potatoes;
- 1/3 fruits such as citrus, dates, apricots, apples;
- 1/3 cereals and fodder.

In terms of water volumes, irrigation water allocation is guaranteed by 75% of groundwater, 24% of surface water, and 1% of treated wastewater (Chaheb, 2010). From the irrigated area, around 40% are small private exploitations from surface wells and shallow drillings, and 60% is equipped for collective irrigation from deep wells, dams and hillside dams. The main public irrigation schemes are located in the basin of the Oued Medjerda main river in the north. The private irrigation areas are mainly located in the traditional areas of irrigation Northeast (Cape Bon) and Central (the Kairouanais, Sidi Bouzid).

Table 5.4 Irrigated area in Tunisia since 1990 and source of irrigation water (Hamdane, L’irrigation en Tunisie)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eaux de surface (hectares)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Barrages et lacs collinaires</td>
<td>112</td>
<td>127</td>
<td>141</td>
<td>171</td>
</tr>
<tr>
<td>- Oueds</td>
<td>98</td>
<td>114</td>
<td>127</td>
<td>157</td>
</tr>
<tr>
<td><strong>Eaux souterraines (hectares)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Nappes phréatiques</td>
<td>183</td>
<td>200</td>
<td>220</td>
<td>225</td>
</tr>
<tr>
<td>- Nappes profondes</td>
<td>125</td>
<td>133</td>
<td>136</td>
<td>135</td>
</tr>
<tr>
<td><strong>Eaux usées traitées</strong></td>
<td>58</td>
<td>67</td>
<td>84</td>
<td>90</td>
</tr>
<tr>
<td><strong>Total (hectares)</strong></td>
<td>301</td>
<td>334</td>
<td>368</td>
<td>406</td>
</tr>
</tbody>
</table>

* estimated

Table 5.4 shows the evolution of irrigation area since 1990. Nowadays further expansion of irrigation is mainly limited by the availability of water resources. Fig. 5.5 shows the main irrigation perimeters in the country.
Irrigation schemes are managed by the Groupement de Développement Agricole (GDA, Agricultural Development Groups).

Irrigation methods

The following irrigation techniques are applied in Tunisia:
- Surface irrigation is applied on 70% of the irrigation area. Efficiency is in the order of 70% for improved gravity irrigation.
- Drip irrigation has become more important in Tunisia (10,000ha equipped in 1995 and 55,000ha in June 2001, and is subsidized. Efficiencies are around 90 to 95%, but the uniformity of watering depends on the choice of equipment and its hydraulic characteristics.
- Sprinkler irrigation. Sprinklers are frequently used for irrigation of cereal crops, forage and some vegetable crops. The hydraulic efficiency is around 85 to 90%.

Water saving in irrigation

A comprehensive national program for saving water in irrigation began in 1995 (Programme National d'Economie d'Eau en Irrigation, PNEEI). The target set by the implementation of various programs is to achieve an overall efficiency in irrigated agriculture surrounding the rate of 85% in distribution (Plan Blue, 2011). Under the program, significant financial incentives are provided to promote efficient irrigation techniques. The water subsidies can represent, for small size farms, up to 60% of the costs. This strategy within ten years allowed the stabilization of the water demand from irrigation, despite the expansion of the irrigated area at the national scale. Some effects of the national water saving strategy as comparison between 2000 and 2010 are shown in Table 5.5.
Within the framework of the Water Sector Investment Programme “PISEAU” (Programme d’investissement dans le secteur de l’eau), the Ministry of Agriculture is rehabilitating and improving the existing irrigation schemes (see below).

Table 5.5 Effects of the national water saving strategy, comparison between 2000 and 2010 (source: Utilisation de l’eau ppt)

<table>
<thead>
<tr>
<th></th>
<th>Year 2000</th>
<th>Year 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated:</td>
<td>360 Mha * Area of Perimeters</td>
<td>410 Mha</td>
</tr>
<tr>
<td>Area equipped with water-saving</td>
<td>223 Mha, 62% of the area</td>
<td>360 Mha, 88% of the total</td>
</tr>
<tr>
<td>systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption of irrigation water</td>
<td>2123 m3</td>
<td>2100 m3</td>
</tr>
<tr>
<td>Average consumption m3/ha/year</td>
<td>5900</td>
<td>5122</td>
</tr>
<tr>
<td>Additional area of IP created</td>
<td>50 Mha</td>
<td></td>
</tr>
<tr>
<td>Additional area equipped</td>
<td>137 Mha</td>
<td></td>
</tr>
<tr>
<td>Areas rehabilitated and modernized</td>
<td>30Mha</td>
<td></td>
</tr>
</tbody>
</table>

**Summary of challenges in the agricultural sector of Tunisia**

The main bottlenecks in water and agriculture in Tunisia can be listed as:

- Overexploitation of groundwater. Exploitation of groundwater has increased by 250% in the past 40 years. Around 80% of the renewable water goes to irrigation, and around 80% of this is coming from groundwater. Groundwater pumping for agriculture reaches 90% of sustainable levels (Besbes et al, 2010). In the southern part of the country where groundwater is shared between Libya, Algeria and Tunisia groundwater, fossil water is pumped from depths of over 300 meters (Personal communication EU - Pommier).
• Large fluctuations in agricultural production. A large part in Tunisia is rainfed (70% of agriculture rainfed, mainly grains and olive trees). The climatic fluctuations induce strong fluctuations in rainfed agricultural production.

• The use of rain in rainfed agriculture is not optimized. In addition, investments in rainfed agriculture are lagging behind. So far, there has been more focus on irrigation than on rainfed agriculture. Why subsidize irrigation and not rainfed agriculture?

• Water stress: Currently, water availability is 460 m³ per capita per year. According to Plan Blue (Plan Blue, 2011), this will be 360 m³ in 2030. The water demand is expected to exceed the supply of water around the period 2020-2030. The mobilization of surface and underground water resources is almost complete;

• Pollution of surface water / groundwater;

• The agricultural population is decreasing. The average of age of farmers is increasing rapidly as young people migrate to the city (Worldbank, 2006).

• Fragmentation of information in different Ministries. Each department has a section for data and databases. A lot of data are available, but how to use them for decision making in integrated water resources planning? (Personal communication Ministry of Agriculture - Lebdi).

5.2 National and regional plans, policies

The Ministry of Agriculture and Hydraulic Resources (Ministère de l'Agriculture et des Ressources Hydrauliques et de la Pêche (MARHP) sets policies concerning conventional water resources in Tunisia, while the Ministry of Environment and Sustainable Development governs sanitation, wastewater and environmental planning.

Tunisia’s policies are directed towards the development and mobilization of water resources, water saving and the control of demand, the development of non conventional water resources and the protection against pollution. For this, the following strategic plans were developed:

Water master plans

In Tunisia, the National Water Program was adopted by the government in 1995. This program aims at efficient and economical valorization of water use, and maintaining water demand to a compatible level with regard to the available resources. The program includes the improvement of water use efficiency of collectively irrigated areas and the improvement of individual irrigation systems. A master plan for water use has been implemented for each of the country’s three natural regions the north, the centre and the south. The master plans include provisions on the transfer of surface and groundwater and on flood protection for large urban centres.

Three main strategic plans were implemented:

• The 10 years strategy of water resources mobilization initiated for the 1st time in 1990, the Decennial Water Resources Mobilization Strategy (1990–2000),

• It's complementary strategy for water resources mobilization (2001–2011). The strategy 2001-2011 aims to mobilize 95% of conventional resources by building dams, reservoirs and flood runoff infrastructure, and to develop non-conventional resources such as recycled and desalinated water.

• The long-term strategy (Water Strategy 2030) mainly builds up on the Water Master Plans for the north, center and south of Tunisia. The Water Strategy 2050 is under preparation.

Water saving programs in agriculture

Water saving is promoted and implemented under Tunisia’s water saving program: Programme National d’Economie d’Eau en Irrigation, PNEEI (described above). PNEEI promotes the use of more efficient techniques at field scale, where the PISEAU programme (Programme d’investissement dans le secteur de l’eau) addresses the irrigation perimeter scale (infrastructure). The programme PISEAU is a series of investment projects in the water sector that started in 2001. The programme focuses on infrastructure and rehabilitation of existing irrigation
perimeters and the development of new perimeters. The programme is financed by the Worldbank and KfW development bank. PISEAU II (2009-2013), the follow-up, aims at an integrated water resources management and the improvement of rural living conditions.

**Tunisian National Water Information System (SINEAU)**

The Sineau (système d’information national sur l’eau) is a unifying tool of information systems on water in Tunisia. The SINEAU aims to:

- Facilitate management and sharing of information on water and soil,
- Integrate the different aspects to understand the current state of water resources, to follow their evolution
- Help them to better use the data and improve decision-making.

SINEAU is also a tool of the 2nd Investment Plan for the Tunisian water sector (PISEAU II), especially for monitoring and assessment of the various activities foreseen as well as for the environmental impact of this plan.

**Agricultural investment programmes**

Unlike Morocco and Algeria, Tunisia does not have an investment programme specifically for agriculture. There is however a programme for economic improvement, which includes agriculture. In this programme, development of the private sector is stimulated as well as foreign investments in agriculture. In addition, the Agricultural Investments Promotion Agency (APIA) exists. APIA is in charge of promoting private investment in order to increase the production and to improve the productivity within agriculture.
6 Libya

Note: For the preparation of this report, no visits could be paid to Libya. There has been no personal communication, and no access to national reports. Hence the description below is very limited. Main sources are the country profiles from FAO and the Worldbank, a note from a workshop “Current Status and the Way Forward demonstrated by National, Regional and International Experiences” in Tripoli in April 2007, and Salem, 2009.

6.1 Water and agriculture

Libya depends almost entirely on imports for domestic food consumption. Agriculture is a small contributor to the country’s GDP; Oil represented 98% of Libya’s GDP in 2010 (Worldbank country profile Libya).

The agricultural area is estimated at 15,550,000 ha (FAO, 2009 estimate). The main agricultural activities are the cultivation of vegetables, fruits and cereals, and livestock production.

Libya’s primary agricultural water source is the Great Manmade River project. The Great Man-Made River (GMR) is a network of pipes that supplies water from the Sahara Desert in Libya, from the Nubian Sandstone Aquifer System fossil aquifer. The construction began in 1984, and it is the world’s largest irrigation project (Guinness World records).

![Schematic drawing of the networks in the GMR project](source: wiki)

Fig. 6.1 Schematic drawing of the networks in the GMR project (source: wiki)

This long-distance transfer of water from the vast desert fossil aquifers in the south of the country represents a huge financial commitment. With a rapidly growing population, the extra water will provide only short term relief to the problem of growing urban demand, and even more costly desalination supply solutions will soon become essential.

Libya faces one of the severest water scarcity problems in the world. With virtually no rainfall except in the narrow coastal belt, the country has increasingly relied on its groundwater resources. In coastal areas these resources are renewed by rain each year, but the country also has vast non-renewable reserves of water underlying the desert. For a number of years, demand for water has far exceeded supply. As a consequence, the country has experienced heavy over-drafting and mining of aquifers associated with growing problems of aquifer depletion, quality deterioration and saline water intrusion.

Water resources
Libya has practically no surface water resources. Surface water contributes to less than 3% of the current water resources (Salem 2009). Libya relies almost totally on groundwater (97%). Water for irrigation is mainly obtained from groundwater through drilled wells ranging in depth from less than 100 m to over 1000 m. Centre pivot irrigation is the most common irrigation in the desert and can easily be detected by the green circles (Fig 6.2).

Fig 6.2 Greening the desert: Center pivot irrigation in the south-eastern Al Khufrah Oasis (Google Earth)

Renewable groundwater resources are retained in the Northern aquifers of the Gefara plain, Jabal Akhdar and parts of the Hamada and Central zone area. The non-renewable groundwater resources are those belonging to the great sedimentary basins of the Kufra, Murzuk, Sarir and the Hamada (Table 6.1). These basins are occupying the Southern part of the country and fall under severely arid conditions.

Table 6.1 Water supply and demand in Libya in billion m3 per year (source: Salem, 2009)

<table>
<thead>
<tr>
<th>Water resources</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water</td>
<td>0.170</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Renewable 0.650</td>
</tr>
<tr>
<td></td>
<td>Non-renewable 3.00, for the different plains:</td>
</tr>
<tr>
<td></td>
<td>- Gefara Plain 0.025</td>
</tr>
<tr>
<td></td>
<td>- Jabal Akhdar 0.025</td>
</tr>
<tr>
<td></td>
<td>- Kufra and Sarir 1.3</td>
</tr>
<tr>
<td></td>
<td>- Hamada 0.150</td>
</tr>
<tr>
<td></td>
<td>- Murzuk 1.5</td>
</tr>
<tr>
<td>Total supply</td>
<td>3.820</td>
</tr>
<tr>
<td>Total demand</td>
<td>5.607 (2010 value)</td>
</tr>
</tbody>
</table>

The large deficit in the water balance is fulfilled through over-exploitation of the coastal aquifers in the first place as well as from the inland aquifers. This has already introduced major problems, such as sharp decline in water
levels, and increase in salinity. The seawater intrusion front along the NW coast is advancing at an alarming rate and has already invaded 10 km inland in the Tripoli region. The effect of this encroachment is not only irreversible but also affecting about half of the Libyan population and more than half the irrigated agriculture (Salem 2009).

The use of unconventional water sources is common practice in Libya, such as desalinated water and treated wastewater effluents.

**6.2 The National Strategy for Water Resources**

Libya is aware of the risks and challenges it faces in the water sector. In recent years an inter-departemental team appointed by the General Peoples Committee (GPC) has produced a National Strategy for Water Resources Management 2000-2025, and this has been adopted by the General (National) Planning Council. The Strategy identifies institutional, technical and legislative measures as the key response needed to correct the situation. Priorities are to improve sector governance and institutional capacity by assigning responsibility under the Strategy for integrated water resources management to a single agency, the General Water Authority.
7 Maghreb challenges and opportunities

7.1 State of agriculture and water resources

The Maghreb countries have several natural resources that offer plenty of opportunities for agricultural development: Availability of arable land, the generally temperate Mediterranean climate with year-round production possibilities, and a growing consumer market.

The Maghreb region is a semi-arid to (hyper) arid region. All Maghreb countries have a water potential per capita which is less than 1000m3, the level generally agreed to represent water scarcity conditions. A main challenge to increase the agricultural productivity in the region is water scarcity due to irregular rainfall patterns, an increased demand of water because of a fast growing population, competition between different water user groups, and challenges in water quality. According to FAO the water scarcity has reached a critical point in the region. This effect is already materializing, and the dependency on rainfall makes the Maghreb countries extra vulnerable to climate changes. In the future the countries are urged to be better prepared for periods of severe drought.

The Maghreb countries depend mainly on rainfall and partially on groundwater. Rapid development of groundwater use in the Maghreb has resulted in significant agricultural growth, and sustainability is now at risk (ref: AfDB brief 2011).

Table 7.1 summarises the water resources for the Maghreb countries.

Table 7.1 Water resources in the Maghreb (billion m3/year)

<table>
<thead>
<tr>
<th></th>
<th>Renewable water</th>
<th>Water potential</th>
<th>Resources used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Of which surface water</td>
<td>Of which groundwater</td>
</tr>
<tr>
<td>Algeria</td>
<td>11.7 (1)</td>
<td>10.15 (2)</td>
<td>1.52 (2)</td>
</tr>
<tr>
<td>Morocco</td>
<td>20.7 (6)</td>
<td>16.5</td>
<td>4.2</td>
</tr>
<tr>
<td>Tunisia</td>
<td>4.2 (1)</td>
<td>2.7 (8)</td>
<td>1.5</td>
</tr>
<tr>
<td>Libya</td>
<td>0.6 (1)</td>
<td>0.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Data sources
1 Plan Blue 2009
2 Aquastat 2008
3 Ministry of Water Resources Algeria, 2011
4 AfDB 2011
5 El Gueddarl, A.B.S. and M. Arrifi 2009
6 SEEE 2011a
7 ONAGRI 2011
From the table it can be concluded that Morocco and Algeria have some renewable water resources left that can be mobilised.

Morocco has the highest freshwater potential. At present, the mobilisation rate (ratio of mobilised water to the potential) is estimated at 66% (19.2/29). This includes both surface and groundwater; For groundwater, there is an over abstraction. Various sources report that the balance between water demand and supply will be maintained until 2030 (UN, 2005). SEEE expects that most of the river basins will suffer from water deficit by 2030 (SEEE 2011).

The mobilisation rate for Algeria is lower than Morocco and estimated at 55% (6.4/11.7). Algeria has potential for further mobilisation of its (surface) water, however some aquifers are already overexploited.

Tunisia has almost completed the mobilisation of water resources, and the water use is only slightly lower than the potential. The country mobilised most of its water resources with a mobilisation rate of 97% of (4.1/4.2). It is expected that in the period 2020-2030, an imbalance will appear between the available water resources regularized and the total water demand of the country (Lebi, 2009; PAPS EAU, 2010).

Libya has limited water resources and has focused mainly on non-conventional water resources to increase water supply, and by the exploitation of non renewable water (fossil water).

### 7.2 Facing the challenges

As stated by the Worldbank, the MENA region has much to be proud of in its water management. The countries of the region have made significant progress improving water policies and institutions. They can learn from their own and their neighbors’ successes and other regions can also take advantage from the experiences and knowledge in the Magreb (Worldbank, 2006).

**Meeting the challenges of the Twenty-First Century**

The Maghreb countries face common challenges: Rapid urbanisation, population growth and the fact that agricultural expansion has put a considerable burden on the environment and is depleting natural resources. The Maghreb governments try to counteract these trends by reforms and national development plans.

In Algeria, the industrial sector has been a priority for a long time, resulting in a favorable economic climate. Algeria has a high dependency on import of agricultural products. The agricultural sector recently has been put back on the agenda by the national plan for agricultural development. With the land and water degradation the country is facing, the need for a sustainable development is acknowledged. New investments in the agricultural sector are needed.

In Morocco, agricultural development is a major challenge and huge steps have been taken. Morocco is advanced in hydraulic infrastructure (barrages) and the country is able to control and divert the water reasonably well. The country imports and exports products to find an equilibrium to use its position for the best. There is a mismatch between water availability and water demand in some regions. For instance, the area with the least available water (Sous-Massa) in Morocco exports the highest amount of tomatoes. This paradox is acknowledged and studies are ongoing to determine which areas are most suitable for agriculture.
Tunisia is the Maghreb country most threatened by water shortage, both economically and socially (ref. CIHEAM 2006). The water resources in Tunisia are almost entirely mobilized, and the country is obliged to apply new concepts. Tunisia is taking measures on water saving, mobilization (water transfers, aquifer recharge), development of non-conventional water resources and small scale projects on water harvesting. The most important challenges are related to a long term view of the agricultural policy. Tunisia’s agriculture is based on subsidised products (e.g. soft wheat) in which Tunisia is not competitive, however initiatives have been started to focus more on quality of products and the value added by the product.

The common challenges for a sustainable agricultural development for the Maghreb countries are:

Water scarcity and irregular rainfall patterns have impact on water availability, and there is an increased water gap projected for the future between demand and supply;

Rainfed agriculture remains important, and its production is vulnerable due to unpredictable rainfall. The challenge is how to boost agricultural production. Traditional, small scale agriculture with low value crops still prevails in all the countries. Characteristic of this type of agriculture is small-scale farming with limited cooperation between farmers;

There is a need for modernising the agricultural sector to improve food security. Food supply from domestic agriculture needs to be enhanced. For instance, agro chain logistics and food processing need to be improved to prevent further food losses;

Excess groundwater use is a main bottleneck in the area, and the effect of over exploitation is visible in all Maghreb countries. Groundwater use represents about 52% of the water used in Algeria, 44% in Tunisia and 14% in Morocco (AfDB, 2011). The main aquifer shared is the Western Sahara Aquifer System, and here large extractions have led to sharp drops in piezometric levels in certain areas.

For most Maghreb countries, responsibilities in water resources planning and management are fragmented. Water management is dominated by government agencies, and the involvement of other stakeholders including civil society remains low and will take time to organize.

The use of non conventional water resources such as treated wastewater is implemented as an alternative to increase water supply. The Maghreb countries are however only turning slowly to desalination of seawater, primarily to meet domestic and industrial needs. Costs are still too high for agricultural use.

Finally, there is a lack in availability of accurate (spatial) datasets on water and agriculture. This is recognised as a common problem in the Maghreb in management and planning of the use of water resources.

### 7.3 Opportunities

**Boosting agriculture: Green Economic Growth**

Food security under water scarcity conditions is a major challenge for the Maghreb countries. The countries have more or less reached their maximum potential in terms of water resources mobilization and further degradation should be avoided. Promoted solutions for water saving such as localised irrigation will not be sufficient to close the water gap (demand-supply) nor to meet the food demands of the Maghreb countries in the near future. The countries have much to offer and new alternatives in economic developments are required - within the existing ecological limits - to ensure a sustainable agricultural growth. This involves private sector development and investments in commercial agriculture.
**Involvement of the private and public sector**

Innovation in the agricultural sector is needed to increase the value added per unit of water (increased water productivity). This involves participation of the private sector for investments to develop new innovative solutions. This was mentioned also during some of the interviews. It is also mandatory at this stage to involve rural civil society in water management planning, resulting in the “golden triangle” (Knowledge sector, Enterprises, Governmental organizations).

To add value to agricultural production the processing industry in the Maghreb countries need further development. A stronger cooperation and organisation of farmers and linking the farmers to the processing activities can boost production and value generated. The governments could stimulate this development by creating a conducive business environment with an efficient infrastructure. The governments can play a role in promoting and ensuring high quality products that fetch high prices.

**Increasing the value of current water use (water saving & crop varieties)**

More innovative techniques are needed to save water, for instance in combination with high value, horticultural crops. The horticultural sector has good potential (climate, infrastructure, proximity to EU markets) and can improve food security as well as add to the export market. The horticultural sector currently is far below its potential, and offers good possibilities to increase income. Horticulture under greenhouse constructions would limit water use and could result in high quality products (tomatoes, ...). Knowledge transfer and capacity building is essential here.

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**Box. More value per m3 water**

It must be realized that even with high yields of 5 tons/ha of wheat with a price of e.g. 0.30€ per kg and with an efficient production of using 400 mm of rain or irrigation, we reach per m3 of water being used an economic yield of 0.38 € per m3 of water. With 1 m3 of water we can produce 60 kg of tomatoes if we use protected greenhouses with reuse of drainage water. With a price of 0.60 € per kg this amounts to an economic yield of 36. - € per m3 of water. It is obvious that such a 100 fold rise in economic output is also associated with an enormous increase in labour requirements. It must be realized that protected horticulture, which has great export potential offers therefore a major opportunity in creating jobs for the Maghreb countries.

In Morocco for instance there are good opportunities for horticultural products in the north eastern part, where sufficient land and water (rainfall) is available. Heavy investments on infrastructure (water storage and roads) are now being made to make the area accessible. This will be needed to relieve the heavily exploited and salinized Agadir area.

**Make a better use of rain**

So far rain-fed agriculture has not received much attention in the development plans and has a low productivity. Rainfed agriculture is mainly used for cereal crops. The irrigated area has increased largely in the past decades, but the area of rain-fed agriculture has remained fairly stable. Investments in rainfed agriculture are lagging behind. Why subsidize irrigation and not rainfed agriculture? More attention should be paid to local (farm) water storage in these areas to limit vulnerability.

**Agro-logistics, food processing and conservation**

Good opportunities exist in the food processing sector and conservation technologies (e.g. supply chain efficiency and logistics, canning, refrigeration) in Algeria and Tunisia. So far poor transport and inadequate conservation has led to losses in food quantities and in food quality in the region.

**Competitive products and diversification**
For the Maghreb, competitive products are underperforming. Farming in the Maghreb still has a prime focus on bulk (subsidized) products such as cereals, which require a relatively large amount of water. Tunisia for instance is competitive in fruits and vegetables, but the country is not capitalizing on its advantage for these products yet.

An opportunity is seen in the protection and marketing of specialized, local products ("produits du terroir"). In Morocco for instance recent initiatives looked into the cultivation of indigenous, medicinal or aromatic products such as saffrane or capre. This provides chances for small, individual rural producers in marginalized areas to link up with the larger production systems. In Tunisia similar initiatives are ongoing to relate products to territory, and protect the origin of the product, like olive oil, dates, and have them recognized by the European Commission.

**Integrated water management and related datasets & tools**

It was acknowledged during the interviews that, at Ministry level, a truely integrated approach would be beneficial, and one would need the necessary tools to support this. This would for instance be crucial for the protection of groundwater resources. In addition, there is a lack of spatial and temporal information on water resources in the Maghreb. This is a basic problem in the MENA region as well as in many other regions of the world (ref Aquastress). Adequate and up to date GIS datasets would provide an opportunity to enhance decision making. Improvement will partly be provided by SEMIDE - EMWIS, a digital database under construction (Catalogue de métadonnées sur l'eau, Plan Blue). The Observatoire du Sahara et du Sahel (OSS) is working towards a shared information system for groundwater resource monitoring (ref: OMAS-UMA tool).

**Further development of non conventional water resources**

The use of non conventional water resources such as the re-use of treated waste water and desalination of brackish water is partly being applied in the Maghreb countries to face water scarcity. Tunisia is most advanced in the re-use of water for agriculture. More research on re-use methods and health standards is needed on this matter.

The Maghreb countries have a good potential for solar energy that can be used to power sea water desalination. Sea water desalinization is practiced in Algeria and Libya, however the costs are still too high to be applied on a large scale.

Some of the electricity generated by e.g. the Solartec project (Tunisia) could be used to increase sea water desalination for agricultural use and to create jobs within the country, rather than simply export electricity.

**7.4 Regional collaboration (knowledge sharing)**

Water is a strategic source for growth in the Maghreb, which requires collaboration and longterm planning. Information sharing and an exchange of expertise is required in this respect. So far a regional collaboration between Maghreb countries is lacking in agriculture (UNESCO, 2007; interviews). To face the challenges in water and agriculture, the Maghreb countries could benefit from a better regional collaboration.

The need and willingness for a future regional collaboration in this field was felt during the interviews. Several topics were raised that could be input for a further regional collaboration / capacity building:

**Algeria**

1. How to determine water requirements under different agro-ecological conditions (INRAA, ..);
2. Water use efficiency for different irrigation technologies (INRAA, ..);
3. Development of techniques for rainfed agriculture, adaptation of irrigation systems to changing weather conditions, supplementary irrigation, conservation of soil water (DDZASA, INRAA, ..).

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4. Valorisation of non-conventional water resources such as desalinization techniques using solar energy (INRRAA, FAO, ..)
5. Drainage and salinity, water quality mapping (INSID, INRRAA, ..).
6. Integrated water resources management concept, governance, decision support, agro-meteo models (ANRH, INRRAA, ..).
7. Apart from knowledge exchange and capacity building in the above mentioned fields, the need for “real” projects was expressed. The idea of a prototype (pilot area) was raised, zone integer, where all the above topics come together.

Morocco

1. Increase water productivity and reduce water demand: Technical expertise is required, and other innovative methods for water saving need to be looked at;
2. Training on choice of crops, how much water they use;
3. Food processing: Renewing conservation and packaging of products;
4. Commercializing crop production, revenues, linking to markets (Personal communication, DIAEA)

Tunisia

1. Increase the potential of rainfed agriculture. There should be more attention paid to the importance of rain (green water), and to maximize the potential of rainfed crops such as grain and olive trees (pers comm INAT). There is a lack of research on this issue.
2. Combatting groundwater over exploitation. To control water abstraction from groundwater does not only require administrative measures, but for this also public participation is needed (pers comm Min of Agriculture). Groundwater monitoring and development of tools for groundwater management would be helpful.
3. Water productivity should be improved, and new varieties are needed (pers comm INAT). Tunisia could import rather than produce crops that use high amounts water, create few jobs and trade at low prices.
4. Increase the agricultural contribution to economic growth. The question is how to put agriculture in a better (good) economic position. The quality and added value of the products has to be increased, for instance initiatives are ongoing for olive oil to increase the value (“branding”). Better harvesting and post harvesting techniques (storage, transport etc.) could improve the situation. Incomes from agriculture also have to be increased (pers comm INAT). Private sector development and investments in commercial agriculture also need attention.
5. Efficient water use: better determination of water demand. Tunisia has several agro-climatic zones, and each zone needs a different approach. Irrigation supplies do not always match the water requirements, and are not adapted to the different climatic regions, leading to losses. Knowledge is needed on the estimation of water requirements. This issue is even more complex in an oasis system characterized by a specific microclimate (pers comm Min of Agriculture).
6. Non conventional water resources. More water should be produced instead of mobilizing more water (pers comm Min of Agriculture). Water re-use is becoming more and more important in Tunisia. More knowledge is needed on the re-use of drainage water (pers comm INAT). Infiltration of treated waste water as being done in the Netherlands could be a good topic (pers comm Bleichrodt). The use of treated waste water also requires proper education on safety and health.
7. Water governance and institutional water mechanisms. A more efficient water use does not only involve technical aspects but also a proper institutional setting. Tunisia is in the process to review the water code, and another form of governance is needed. Civil society is needed for this; Civil society is not involved in strategic development (pers comm Min of Agriculture).
8. Capacity building. Combined capacity building, technical and organisational improvements are needed for a sustainable system (pers comm Min of agriculture). Capacity building was also raised by GWP MED (pers comm GWP Med).
It can be concluded that many of the points identified by the individual countries are shared items, which can be labelled as common topics for the Maghreb countries. It would therefore be more effective to collaborate on these points and achieve faster progress in developing an agricultural sector providing more jobs and making a strong contribution to the national economy.

7.5 Collaboration with the Netherlands

The Dutch policy is concentrating on its top sectors which include Water, Food and Horticulture. This links very well with the current developments in the Maghreb. The main areas of co-operation between the Maghreb countries and the Netherlands could be identified as follows:

- **Knowledge infrastructure**
  First of all, the farmers require education, direct support by extension services and knowledge support by a strong research programme. A strong coordination between this education, extension services and research is needed. The Netherlands strategy to develop this kind of cooperation has enabled the enormous development of agriculture and horticulture in the Netherlands. Sharing experience and exchanging knowledge between the Netherlands and the Maghreb could help the Maghreb in implementing their national strategies in this respect.

- **Technology for modern agricultural practices**
  Highly productive agriculture and horticulture requires technology, including high quality inputs, like plant breeding materials, water treatment systems, high-tech greenhouse structures, high-tech processing and storage techniques, etc. The Maghreb countries could adapt these technologies to their own needs and necessities to boost their agricultural output and to optimise waste water management.

- **Food waste management and agro logistics**
  Waste on agricultural produce is in many cases up to 50% in the region. The main reason is lack of sound agro logistics and efficient cooling/storage facilities. Due to the importance of the export and import of the agriculture related goods and services the Netherlands have developed a profound knowledge on this subject matter.

- **Market access improvement and private sector investment**
  The government has an important role to play, by setting standards in quality and enforcing/supervising these standards effectively. Creating a trustworthy and sound investment environment is moreover a task of the government. Reform and development is however a shared responsibility of the private sector and the public sector. Unnecessary interference of the government in private sector investment and excessive bureaucratic regulations are damaging in attracting local and foreign investment. There are many possibilities to minimize or eliminate these obstacles. The Maghreb is an attractive region for the Dutch agribusiness, given its proximity to the European market and prosperous Gulf region, year-round production possibilities, availability of agricultural land, and the growing consumer market. Considering the long business and trade tradition of the Maghreb countries and the Netherlands, both could learn from a stronger involvement of the business community in a further development of the agriculture sector.

To conclude, although the Maghreb countries face many challenges yet there are tremendous opportunities to increase the agricultural produce value per m$^3$ water. Close collaboration between the governments, the private sector and the knowledge institutes is essential to address the challenges in an integrated manner. For this reason the Netherlands could be a valuable partner. A closer collaboration between the Maghreb and the Netherlands will be beneficial to the Maghreb as well as the Netherlands.
8 Conclusions

This report provides an overview of the current status of water and agriculture in the Maghreb, based on national reports/datasets, international data sources and interviews held at the Ministries in Morocco, Algeria, and Tunisia.

Agricultural development plays an important role in the economies of the Maghreb countries. Food demand is increasing in the Maghreb and consumption patterns are changing. The countries face common challenges in their strategy to improve food security. The most significant challenges are a rapid population growth, urbanisation, dependency on rainfed agriculture with fluctuating yields, water scarcity, increased water demands, and challenges in water quality. Water scarcity has reached a critical point in the region, and the dependency on rainfall makes the Maghreb countries extra vulnerable to climate changes. Groundwater has been a key driver for agricultural growth in the region, and sustainability is now at risk. The national governments try to counteract these trends by reforms in their agricultural development plans but did not succeed in tackling the problems so far.

The Maghreb offers plenty of opportunities for agricultural development: Availability of arable land, a temperate Mediterranean climate with year-round production possibilities, and a growing consumer market. Morocco and Tunisia have heavily invested in mobilising water resources, followed later by Algeria. Morocco has the highest freshwater potential. Both Morocco and Algeria have some potential for further mobilisation of its (surface) water, however some aquifers are already overexploited. Tunisia has almost completed the mobilisation of water resources, while Libya is almost completely depending on fossil water and non conventional (treated) water for agriculture.

Food security under water scarcity conditions is a major issue for the Maghreb countries. Water saving programs and localised irrigation are among the main promoted solutions, accompanied with subsidies and technical support for farmers. Such techniques improve productivity (value per m³ water) but do not always lead to water saving or higher efficiency at a regional scale. New alternatives for agricultural development are required to ensure a sustainable agricultural growth which closes the (future) gap between demand and availability of water.

Food supply from domestic agriculture needs to be enhanced to promote self-reliance. In the Maghreb, competitive products are underperforming and there is still prime focus on bulk products, which require a relative large amount of water. Innovation is needed to add value to agricultural production - within the existing ecological limits - to establish a sustainable development (Green Economic Growth). This involves participation of the private sector for investments to develop new innovative solutions. The horticultural sector has good potential (climate, infrastructure, proximity to EU markets) and can improve food security. Horticulture under greenhouse constructions would limit water use and can result in high quality production. Another opportunity is seen in the protection and marketing of local, high value products which provides chances for small, individual rural producers in marginalized areas to link up with the larger production systems.

In addition to increasing productivity and growth, enhanced agro-logistics and food processing techniques are needed to prevent food losses that currently occur in the Maghreb countries.

Agribusiness offers many opportunities for cooperation in the Maghreb, where patterns of production and consumption are similar and proximity is a potential asset. The countries face the same challenges and would have a lot to gain from joining forces on agricultural issues. Capacity building and knowledge exchange related to agribusiness development, water saving technologies, improved datasets & tools for regional water resources assessments and monitoring are key topics for future regional collaboration.
The growing young population in the Maghreb and the relation to food security is an issue. Socio-demographic variables and their relation to agriculture however have been outside the scope of this study.

Although the Maghreb countries face many challenges yet there are good opportunities for the implementation of a sustainable agriculture that reduces water use and adds to the agricultural value chains. Water management in the Maghreb is dominated by government agencies, and the involvement of the private sector and civil society remains low and will take time to organize. Close collaboration between the governments, the private sector and the knowledge institutes is essential to address the challenges in an integrated manner.
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**ANNEX 1**

**List of interviewed persons**

Morocco

<table>
<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Mr. Rahali (replacing Ait Kadi)</td>
<td>Ministry of Agriculture, Conseil Général du Développement Agricole</td>
<td>Rabat, 16 May 2011</td>
</tr>
<tr>
<td>Mr Moulid</td>
<td>Ministry of Agriculture, Director Direction de l'irrigation et de l'aménagement de l'espace agricole (DIAEA)</td>
<td>Rabat, 16 May 2011</td>
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<tr>
<td>Mr Adil Bennour</td>
<td>Ministry of Agriculture, Director Direction de l'irrigation et de l'aménagement de l'espace agricole (DIAEA)</td>
<td>Rabat, 16 May 2011</td>
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<tr>
<td>Mr Fouad Rachidi</td>
<td>Morocco Economic Competitiveness Program (MEC)</td>
<td>Rabat, 17 May 2011</td>
</tr>
<tr>
<td>Mr Mustapha El Haiba</td>
<td>Morocco Economic Competitiveness Program (MEC)</td>
<td>Rabat, 17 May 2011</td>
</tr>
<tr>
<td>Mrs. Chamim Loubna</td>
<td>Chef de la Division de la Cooperation Direction de la Strategy et des Statistiques</td>
<td>Rabat, 13 May 2011</td>
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Algeria

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<tr>
<td>Dr Ramdane</td>
<td>ANRH</td>
<td>Algiers, 28 June 2011</td>
</tr>
<tr>
<td>Nabil Assaf</td>
<td>FAO</td>
<td>Algiers, 27 June 2011</td>
</tr>
<tr>
<td>Mr Bougueroua Omar</td>
<td>Directeur de l'Hydraulique Agricole DHA Ministry of Water Resources</td>
<td>Algiers, 27 June 2011</td>
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<tr>
<td>Mr Redjel</td>
<td>Direction de Développement des Zones Arides et Semi Arides DDZASA, Ministry of Agriculture</td>
<td>Algiers, 27 June 2011</td>
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<tr>
<td>Mr Hocine Irekti</td>
<td>INRAA, Ministry of Agriculture</td>
<td>Algiers, 28 June 2011</td>
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<td>xx</td>
<td>INSID</td>
<td>Algiers, 28 June 2011</td>
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<tr>
<td>Mr Guernis Messaoud</td>
<td>Directeur se Services Agricole de Blida</td>
<td>Blida, 29 June 2011</td>
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Tunisia

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<tr>
<td>Fethi Lebdi</td>
<td>Ministry of agriculture</td>
<td>Tunis, 6 June 2011</td>
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<tr>
<td>Sarra Touzi</td>
<td>GWP Med</td>
<td>Tunis, 6 June 2011</td>
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<tr>
<td>Pieter Bleichrodt</td>
<td>AHT</td>
<td>Tunis, 8 June 2011</td>
</tr>
<tr>
<td>Denis Pommier</td>
<td>EU</td>
<td>Tunis, 8 June 2011</td>
</tr>
<tr>
<td>Name</td>
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<tr>
<td>Abdelwahab Belloum</td>
<td>FAO</td>
<td>Tunis, 7 June 2011</td>
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<tr>
<td>Abdelkader Hamdane</td>
<td>Maison de l'eau INAT</td>
<td>Tunis, 6 June 2011</td>
</tr>
<tr>
<td>Mr. Zacharie Méchali</td>
<td>Agence Française de Development (AFD)</td>
<td>Tunis, 9 June 2011</td>
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