Morocco

COUNTRY PROFILE: THE KINGDOM OF MOROCCO

LOCATION

Morocco is located on the North-West edge of the African continent, between latitudes 21°N and 36°N and longitudes 1°W and 17°W. The country has a total area of nearly 711,000 km^2. This includes 2,934 km of costs on the Atlantic Ocean on the West, and 512 km of coast on the Mediterranean sea to the North. It borders Algeria to the East and South-East and Mauritania to the South-West. According to the latest 2014 census, its population is estimated at nearly 34 million people.

CLIMATE

Morocco is characterized by a wide variety of topographies ranging from mountains and plateaux, to plains, oasis and Saharan dunes. For this reason, the country experiences diverse climatic conditions with large spatial and intra- and inter-annual variability of precipitation. Morocco faces irregular rain patterns, cold spells and heat waves increasingly resulting in droughts, which significantly affects agriculture.

Generally, three main environmental zones are recognized in Morocco:

The coastal plains and plateaus: The coastal region to the north has a Mediterranean climate, with hot dry summers and mild wet winters; rainfall varies from 800 mm in the north (Gharb plain) to less than 200 mm in the Sous valley in the south.

The highland areas of the Rif and Atlas mountains: Climate varies with altitude in the mountainous areas of Morocco, which make up 80% of the land. Mountain regions have higher rainfall, colder temperatures and winter snow where elevation is more than 2,000 meters.

The desert to the south east: This region is characterized by the scarcity of rain, high summer temperatures and very cold winter nights. The pre-Saharan oasis zones and areas and sub-arid pastoral steppes and desert areas are also characterized by higher specificity:

- The Pre-Saharan zone: this zone captures very low rainfall (100 to 200 mm). Two irrigated areas in this zone include "Ourzazate and Tafilalet".
- The Saharan zone: this region receives less than 100 mm which results in very limited agriculture practiced along with livestock production.

Temperatures in the coastal regions range between 22-25°C in the summer (JAS) and 10-12°C in the winter. Temperatures throughout the year are considerably lower than this range at the higher altitudes of the Atlas Mountains. The wet season lasts between November and March, affecting only the north of Morocco, with an average of 50 to 100mm per month.

The interior border of Morocco experiences marked seasonal temperature variations, with average temperatures of 25 to 30°C in the summer dropping considerably in winter to less than 15°C.

Moreover, the prevailing climatic conditions in Morocco are characterized by extended periods of dry spells and wet periods with a regime of irregular precipitation, with flash flood, associated with low probabilities of occurrence. Inter-annual rainfall variability is also high. As a result of aridity and rainfall variability, Morocco is extremely vulnerable to drought which represents a structural recurrent phenomenon. Several studies indicate that global climate change will add more to the existing problems. Indeed, the country is already facing more frequent, more intense and longer drought episodes.

AGRICULTURE

The agricultural sector is of particular strategic importance in Morocco. It accounts for 14 to 20% of the GDP and represents 43% of all employment and 78% of rural employment. However, 80 % of arable lands are located in arid or semi-arid areas and only 15 percent of the country's lands are irrigated. Thus, Agriculture in Morocco is characterized by a dichotomy between traditional and market agriculture. The traditional sector consists of small farms in rainfed areas involved predominantly in cereal, legume, and livestock production. Rural population that represents nearly 44% of Moroccan inhabitants is mostly composed of small subsistent farmers whose production depends almost entirely on rainfall. The gross annual agricultural product is therefore strongly correlated to the annual rainfall and, due to the economic weight of the agricultural sector, each rainfall deficit impacts the whole economy of the country. Market agriculture is concentrated in irrigated areas and although representing only 15% of agricultural lands, contributes to 45% of the GDP and 75 % of agricultural exports. Farm surveys indicate that about 70 percent of farms have less than 5 hectares while the average size farm is 5.7 ha

Overall, Moroccan agriculture operates through a mixed and integrated crop/livestock system, representing the main source of income for the majority of rural households. Most arable land and rangeland are located in areas receiving less than 400 mm of rainfall, where cereals and small ruminants mainly sheep are integral components of an extensive dryland production system. The following table presents the main farming systems.

Table 1 : Major Moroccan farming systems (ISCRAL, 1994)

Farming Systems	Major crops	Major features
Irrigated	Fruits, vegetables, industrial and cash crops	The system contains both large and small-scale irrigation schemes
Highland mixed	Cereals, legumes, sheep, off -farm work	There are two subsystems; (a) rainfed cereal and legumes plus tree crops (fruits and olives) on terraces, (b) livestock (mostly sheep) on communally managed lands.
Rainfed mixed	Tree crops, cereals, legumes, off -farm work	Supplementary winter irrigation may be used for wheat and on summer cash crops.
Dryland mixed	Cereals, sheep, off –farm work	Livestock, including cattle and small ruminants, interact strongly with the cropping and fodder system.
Pastoral	Sheep, goats, barley, off -farm work	
Arid	Camels, sheep, off -farmwork	

Agriculture lands covers 8.7 million hectares providing a diverse agriculture production. About 43% of arable land is devoted to cereals, 7% to plantation crops (olives, almonds, citrus, grapes, dates), 3% to pulses, 2% to forage, 2% to vegetables, 2% to industrial crops like sugar beets, sugar cane, cotton and oilseeds, and 42% to fallow. The following points give a brief overview of the main agricultural sectors:

- Cereals sector:

The cereals sector is one of the main sectors of agricultural production in Morocco. It plays a variety of roles with regard to annual grain-sown areas of arable land, formation of the Gross Agricultural Product, employment in rural areas and utilisation of industrial processing capacities. 90% of cereals acreage are located in rainfed areas and grown in rotation with other annual crops, the main ones being legumes (beans, chickpeas, lentils), industrial crops, fodder crops or fallow. Common wheat represents on average almost 47% of the gross value of cereals, followed by durum wheat (27%), barley (23%), maize (2%) and other cereals (sorghum and rice)(1%). Mean yields remain low (10-12 qx/ha) and far beyond each region potential.

- Sugar Sector

The national sugar sector holds a strategic place thanks to its contribution to the nation's food security, to its creation of employment in the agricultural and industrial sectors. Sugar crops are grown by over 80,000 farmers in the irrigated perimeters of the Doukkala, Tadla, Gharb, Loukkos and Moulouya regions. The sector depends on a surface area of 60,000 ha planted in sugar beets and 16,800 ha planted in sugar cane. As for production, the current average is 3 million tons of beets and 0.90 million tons of sugar cane, which allows the for production of 460,000 tons of sugar representing 43% of domestic needs.

- Citrus Sector

Morocco's citrus areas in the 2011/12 season were estimated at 96,100 ha, of which 45,500 ha of oranges, 42,100 ha of small citrus fruits and 8,500 HA of other citrus (lemons, limes and grape fruits). Morocco is classified as the 4th largest fresh citrus exporting country in the world and the 2nd largest of clementine type exporter. There are more than 47 citrus varieties currently existing in Morocco, Navels, Valencia late and clementines are the most represented. Several new hybrid varieties are gaining popularity compared to local varieties. These varieties have the advantage of being a higher quality and late harvest that extends the season through February and thus increases their availability to the export markets. Average yields are estimated at 23.7 T/ha for small citrus and at 23 T/ha for oranges.

- Olive trees sector

As in the entire Mediterranean basin, the Moroccan olive industry is very ancient and olives and olive oil form an integral part of the diet. In the early 1960's the area dedicated to olives was only 128,500 hectares but in 2009, the total olive trees area represented 735,000 Ha; with a rapid growth since 2005 and a prevision of 900 000 ha by 2014. Olive production occurs throughout the country with a very large number of smaller producers. Olives are everywhere with small to medium sized groves on the coastal plains, on mountain slopes, on roadsides and as part of town streetscapes and even in the Saharan oases. Traditional old groves are characterized by small densities (100 to 150 trees per ha), unmanaged trees, very low yields (around one to 2 t/ha), traditional harvest, lack of irrigation or supplemental irrigation whereas new groves are characterized by High (> 150) to Very high (> 1000 or more) densities, perennial irrigation, automatised harvest, Intensive management and High yields.

- Market fruits and vegetable sector

The Moroccan market fruit and vegetable sector covers around 260,000 ha and produce annually around 7 Million tons. It is composed of season crops that are grown in open fields, early-season products for export and industrial crops. Major crops are: Potatos, tomatos, onions, melons, watermelons, carots and turnips. Peppers, mint, zucchni and peas are also important crops. Inter-annual variations of these 12 crops' acreage exist, but these 12 represent 85 to 90% of all Moroccan market products. Early season crops represent the main pillar of this sector. With a mean acreage of 30,000 ha, they represent a total production of 1.5 million tons of fruits and vegetables. Exports represent about 580,000 tons and are mainly oriented towards the European market. Tomatoes account for around 60 % of the exported products, followed by green beans, zucchini, peppers, strawberries and melons.

In 2008, the Moroccan government adopted a strategy to drive and reform the agricultural sector, promote the integration of agriculture into international markets and help agriculture achieve sustainable growth. The strategy was called the Green Morocco Plan. Its implementation relies on two main pillars and a variety of intersecting programs. The first pillar relates to high-yield, intensive and market-related agriculture. The second relates to bolstering the position of small farmers through the proper promotion of crop yield growth and encouraging a shift toward crops that are better adapted to environmental conditions and market demand. The intersecting programs involve water conservation, land ownership and the mobilization of investments.

At present the total area covered by soil survey, is estimated at 20 million ha. It is mostly concentrated in the north and central western part of the county, north of the Atlas Mountains; the French soil classification system (CPCS of 1967) is almost the unique legend used. A schematic general soil map of morocco is available at the scale of 1:2,000,000. (Moussedek, 2014)

Morocco is characterized by several different types of soils, different from one region to another. The following table presents the main types and was derived by the Morocco country profile of FAO.

Table 2: Main Moroccan soil types

Region	Soil
Sais plain	Brown limestone, vertisols, lithosols and regosols
Chaouïa, Doukkala, and Abda plains	rendzines associated with lithosols in the Atlantic coast and isohumic and vertisols in inlands.
Eastern High Plateaux and Moulouya Valley	Sierozems and fluvisols
Rif	brown soils associated with lithosols and regosols or/ vertisols.
Mamora and Zemmour plateau	sandy soil
Middle Atlas	brown soils and rendzinas
High Atlas	lithosols and regosols, in association with brown soils and sierozems
Loukkos	mostly gleysols and brunified
Rharb plain	gleysols and vertisols
Central plateau	in forested areas, soils are brown associated with lithosols and regosols. Elsewhere (Zaer), vertisols and gleysols dominate;
Plains and plateaux of north of the Atlas	lithosols (Rehamnas, Jebilete), sierozems associated with lithosols
Argan zone	soils are mostly lithosols and regosols, associated with fluvisols and saline soils on lowlands;
Presaharan soils	lithosols and regosols in association with sierozems and regs
Saharan zone	yermosols, associated with sierozems, lithosols and saline soils

Source: FAO

Locally, soils are known as:

- **Tirs** which is a dark clay-marl soil known found in the Chaouïa, Doukkala, and Abda plains. It produces good yields of wheat and barley when precipitation is sufficient and can retain enough moisture to support summer pasture.
- ***Hamri*** *which is* a light reddish siliceous soil found throughout the Saïs Plain surrounding Meknès and Fès. It also allows good cereal yields, though it has poor moisture retention.
- ***Dhess*** is the main soil type of the Sebou basin. It is a silt-rich alluvial soil that provides the foundation for much of Morocco's modern irrigated agriculture.
- Other major soil types, less suitable for agriculture, are ***rmel***, a sandy soil found in the Mamora Forest region east of Rabat and along much of the northern coast, and *hrach*, a rocky soil found throughout Morocco's semi-arid regions.

Modelling yield potential, water limited yield potential and irrigated yield potential

For each crop in each country, its harvest area of recent years is classified into different climate zones based on three climatic indices: aridity, seasonality, and length of growing season (van Wart et al, 2013). Crop yields within the same climate zone are assumed to be comparable and similarly attainable for a given soil type. Yield simulations were performed at key locations where observed weather data are available (called reference weather stations or RWS) and crop harvest area is significant (You et al., 2009). RWS were selected iteratively based on harvested area within a 100 km buffer zone (but using 50 km buffer zone for the smaller country of Jordan) until 50% of harvested area was within the buffer zone of all selected stations. This initial RWS selection was reviewed by country experts and stations were added or subtracted based on their expertise. Dominant soil textures and crop management information (sowing date, plant population, cultivar maturity) at district levels were collected in the area surrounding each RWS (Table 1). ISRIC-WISE soil data were used to determine dominant soil textures where observed data or expert opinion on dominant soils were lacking. Weather data were collected from national weather databases and then run through quality control measures as described in van Wart et al. (2015) and in the GYGA protocols.

The WOFOST crop simulation model (Diepen et al, 1989) was used to estimate the Yp, Yw and Ys (yield potential, water-limited yield potential and supplementally irrigated yield potential, respectively) of barley, potato and wheat for each water regime (i.e., rainfed, supplemental irrigation, or full irrigation) for major soil types in the area around the RWS. For wheat simulations, the WOFOST model does not contain a default spring wheat crop data file. Therefore, a default sprint wheat crop data file was created based on growth parameters as reported in Belhouchette et al., 2008 and as specified in the WOFOST default barley crop data file (Table 2). The temperature sum from emergence to anthesis (TSUM1), temperature sum from anthesis to physiological maturity (TSUM2) and the initial total crop dry weight (TDWI; indicative of sowing density) were adjusted so that simulated harvested index (HI) of Yp was close to reported average of 0.45, reported maximum leaf area index was within reported range of between 3-5, and crop matured around the average time farmers' crops were reportedly reaching physiological maturity. For barley, WOFOST's default crop data file was used, and TSUM1, TSUM2 and TDWI were adjusted in the same way as for wheat described above. Lastly, a soil file was developed for each major soil texture identified at each site and used in the WOFOST model (Table 3). Current average amount and timing of supplemental irrigation was reported by country experts and applied to simulations (see Table 4).

Table 1 Site management and soil parameters used in the WOFOST model, years simulated and reported rainfed and irrigated yields at each site for barley (A) and wheat (B)

(A) Site	Country	Sowing date	Growth duration (sowing to harvest)	Major soil texture around site	Years Simulated	Reported irrigated yield (Mg ha^{-1})	Reported rainfed yield (Mg ha^{-1})
BeniMellal	Morocco	8-Dec	180	LOAM	95' - 14'	NA	0.12
BeniMellal	Morocco	8-Dec	180	CLAY LOAM	95' - 14'	NA	0.12
FesSais	Morocco	1-Dec	180	CLAY LOAM	95' - 14'	NA	0.10
Meknes	Morocco	1-Dec	180	SANDY CLAY LOAM	95' - 14'	NA	0.08
Meknes	Morocco	1-Dec	180	CLAY LOAM	95' - 14'	NA	0.08
NadorArwi	Morocco	1-Dec	180	LOAM	90' - 04'	NA	0.12
Nouasser	Morocco	7-Nov	210	SANDY LOAM	95' - 14'	NA	0.22
Nouasser	Morocco	7-Nov	210	CLAY	95' - 14'	NA	0.22
Nouasser	Morocco	7-Nov	210	CLAY LOAM	95' - 14'	NA	0.22
Safi	Morocco	1-Nov	210	LOAM	95' - 14'	NA	0.11
Tanger	Morocco	16-Dec	180	SANDY CLAY LOAM	95' - 14'	NA	0.10
Marrackech	Morocco	1-Nov	210	LOAM	95' - 14'	NA	0.06
Marrackech	Morocco	1-Nov	210	SANDY LOAM	95' - 14'	NA	0.06

(B) Site	Country	Sowing date	Growth duration (sowing to harvest)	Major soil texture around site	Years Simulated	Reported irrigated yield (Mg ha^{-1})	Reported rainfed yield (Mg ha^{-1})
BeniMellal	Morocco	15-Dec	180	CLAY LOAM	95' - 14'	0.49	0.11
BeniMellal	Morocco	23-Dec	180	CLAY LOAM	95' - 14'	0.49	0.11
BeniMellal	Morocco	8-Dec	180	CLAY LOAM	95' - 14'	0.49	0.11
BeniMellal	Morocco	8-Dec	180	LOAM	95' - 14'	0.49	0.11
FesSais	Morocco	1-Dec	180	CLAY LOAM	95' - 14'	NA	0.12
Meknes	Morocco	1-Dec	180	CLAY	95' - 14'	0.30	0.22
Meknes	Morocco	1-Dec	180	CLAY	95' - 14'	0.30	0.22
Meknes	Morocco	1-Dec	180	CLAY LOAM	95' - 14'	0.30	0.22
NadorArwi	Morocco	1-Dec	180	LOAM	90' - 04'	0.33	0.10
Nouasser	Morocco	4-Nov	210	CLAY	95' - 14'	NA	0.18
Nouasser	Morocco	4-Nov	210	CLAY LOAM	95' - 14'	NA	0.18
Nouasser	Morocco	4-Nov	210	SANDY LOAM	95' - 14'	NA	0.18
Nouasser	Morocco	7-Nov	210	CLAY	95' - 14'	NA	0.18
Nouasser	Morocco	7-Nov	210	CLAY LOAM	95' - 14'	NA	0.18
Nouasser	Morocco	7-Nov	210	SANDY LOAM	95' - 14'	NA	0.18
Nouasser	Morocco	15-Nov	210	CLAY	95' - 14'	NA	0.18

Nouasser	Morocco	15-Nov	210	SANDY LOAM	95' - 14'	NA	0.18
Safi	Morocco	1-Nov	210	LOAM	95' - 14'	0.43	0.12
Safi	Morocco	15-Nov	210	LOAM	95' - 14'	0.43	0.12
Safi	Morocco	1-Nov	210	LOAM	95' - 14'	0.43	0.12
Safi	Morocco	1-Nov	210	CLAY LOAM	95' - 14'	0.43	0.12
Tanger	Morocco	24-Dec	180	SANDY CLAY LOAM	95' - 14'	NA	0.07
Marrackech	Morocco	1-Nov	210	LOAM	95' - 14'	0.29	0.07
Marrackech	Morocco	1-Nov	210	SANDY LOAM	95' - 14'	0.29	0.07

Table 2 Parameters changed from defaults in the default WOFOST crop parameter file and source of changed parameter value

Parameters changed from defaults	Wheat file parameter	Source
1). TSUM from sowing to emergence	100	Belhouchette et al., 2008
2). Max temperature for growth	35	Default WOFOST barley crop file
3). initial total crop dry weight [kg ha-1]	120	Default WOFOST barley crop file
4). leaf area index at emergence [ha ha-1]	0.274	Default WOFOST barley crop file
5). maximum relative increase in LAI [ha ha-1 d-1]	0.0075	Default WOFOST barley crop file
6). life span of leaves growing at 35 Celsius [d]	25	Default WOFOST barley crop file
7).extinction coefficient for diffuse visible light	0.48	Belhouchette et al., 2008
8). Correction factor transpiration rate	1.1	Belhouchette et al., 2008
9). Maximum rooting depth[cm]	150	Belhouchette et al., 2008

Soil texture	**SMW***	**SMFCF****	**SM0*****
Loamy sand	0.020	0.174	0.440
Sandy loam	0.069	0.252	0.460
Silt loam	0.090	0.279	0.510
Loam	0.093	0.278	0.500
Sandy clay loam	0.175	0.328	0.430
Silt clay loam	0.168	0.320	0.450
Clay loam	0.261	0.373	0.450
Clay	0.364	0.498	0.540
Silty clay	0.277	0.462	0.510

Table 3 Soil textural parameters used in WOFOST model simulations

*Soil moisture content at wilting point (cm^3 cm^{-3})

**Soil moisture content at field capacity (cm^3 cm^{-3})

***Soil moisture content at saturation (cm^3 cm^{-3})

Table 4 Supplemental irrigation applied to simulations of wheat in Morocco and Tunisia (mm)

Site	**Sowing**	**Heading**	**Anthesis**	**Grain filling**
	Morocco			
Béni Mellal			40	30
Fès-Saiss		40	40	
Nador-Arwi			50	
Nouasser			80	
Safi			60	
Tanger			40	
Marrakech			60	30

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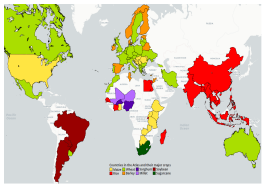

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