Executive Summary Phase 1 Report Morrocco

A pilot study within a regional framework

This study, led and financed by the World Bank, addresses **adaptation to climate change and natural disasters in the Greater Casablanca region and the Bouregreg Valley in Morocco.** It is part of a wider framework to assess the vulnerability of North African coastal cities in view of climate change and natural disasters. This first part of the study constitutes the **Phase 1 Report** regarding the assessment of risks at present as well as for the year 2030.

The study area is defined by the perimeter of the "Schéma Directeur d'Aménagement et d'Urbanisme de Casablanca" (Casablanca development and urban planning master plan) and the official area earmarked for the development of the Bouregreg Valley. The analysis nonetheless mainly focuses on the urban sites of both perimeters.

Natural risks dominated by flooding

In geological terms, the Casablanca and Bouregreg Valley sites belong to the coastal area of the Moroccan Meseta which, at present, is not much seismic. The coastal Meseta is separated from the central Meseta by an ancient fault in the NNE-SSW direction which is currently inactive. On the Bouregreg site, neogenic and quaternary (less cohesive therefore subject to settlement or liquefaction phenomena) formations are thick and the existing poor **geotechnical quality of the ground** contributes to increasing seismic risk. The Bouregreg Valley slopes also show signs of instability due to landslides and rock fall which is also an aggravating factor of seismic risk.

In fact, if there is relatively low **seismic risk** in Casablanca, i.e. an intensity of IV to IV-V for a return period of 50 years, corresponding to inexistent or very little potential damage, the risk level could be slightly increased for the Bouregreg site where slight damage may become visible on the most vulnerable residential areas.

The analysis of historic events and the seismotectonic situation indicates that the western Moroccan coastline is exposed to a relatively high degree of **tsunami risk**. Nevertheless, for an event similar to that of 1969, the return period is around 200 years. The wave height on the western Moroccan coastline is estimated to be less than 1m which, in terms of intensity, corresponds to a 50-year storm surge.

The map of coastal risks, established by comparing the coastline's socioeconomic and environmental stakes/vulnerabilities and the submersion and erosion hazard, shows the **coastal erosion and marine submersion risk** essentially located between the far eastern end of Casablanca and the Mohammedia power plant, on an area with approx. ten kilometres of beaches. In total, 40 to 50 kilometres of coastline are considered to be at a high risk in the study area. These risks are also considered to be high at the mouth of the Bouregreg. The risk of erosion varies according to the type of coastline (whether sandy or rocky) and the mechanisms of change in play (sedimentary inflows and coastal development). The risk of submersion is established on the basis of a 1m storm surge which, along with a high spring tide, may lead to a 50-year submersion depth of 2.77m NGM in Casablanca and 2.65m NGM at the mouth of the Bouregreg.

These are undoubtedly the river **flood** or run-off **risks** which constitute the main natural risk factors for these two study areas. The level of protection in Casablanca is already low at present which corresponds to a return period of just 5 years in the urban areas. Around ten “black spots” have been identified by LYDEC which cause frequent flooding in highly urbanised areas and lead to disruptions in the lines of communication. Flooding in these sectors is due to various factors, such as:

- Poor standard of main water drainage systems, observed for half of them since 1997.
- Absence of a storm water drainage network for two of them.
- Intensified urbanisation of the catchment area for three of them leading to the insufficiency of the water drainage systems in view of increasing flow rates.

Rapid urban development upstream from the existing urban sectors leads to new flood areas due to the incapacity of downstream water drainage systems in handling the additional flow rates and not taking into consideration the principles of development that need to be respected to contain the downstream volumes of water in the newly urbanised areas.

The Bouskoura wadi’s natural bed crosses the Casablanca urban area and is completely urbanised. Its flow area is greatly reduced when it passes through the conurbation since the water drainage system’s capacity is $2m^3/s$ (to be compared to the decennial flow rate of $45m^3/s$). During heavy rainfall, such as in 1996, the city centre was flooded. The difficulty in estimating the characteristic flow rates of the Bouskoura wadi leads to a very wide range of estimates in accordance with the pluviometry taken into consideration and the assessment method used.

The El Maleh wadi provoked catastrophic flooding in November 2002 in the city of Mohammedia. These floods were aggravated by a number of factors such as the occupancy of the flood plain, the presence of obstacles to runoff, and insufficient hydraulic crossing sections. This flood, with an estimated return period of 65 years, upstream from the El Maleh Dam, was strongly tempered by the dam.

With regard to the Bouregreg, detailed hydraulic studies were carried out within the framework of the Bouregreg Valley development project. These studies defined the hypotheses to be taken into consideration for forthcoming studies: hydrological conditions upstream from the SMBA (Sidi Mohammed Ben Abdallah) Dam, flood reduction conditions, simultaneous conditions with the Arach wadi, and downstream conditions. At present, flooding has been generalised in the Bouregreg Valley for the 100-year reference flood; the floods begin in the upstream and central part as from the 10-year flood. The bridges are not submerged for the reference flood.

The **risk of water shortage** is relatively low at present thanks to the important dam construction programme that has been implemented by the Moroccan Authorities for several decades. Water supply to Greater Casablanca is provided by two main sources: the SMBA Dam, on the Bouregreg wadi which supplies 38% of needs, and the El Massira Dam, on the Oum Er Rabia, for the remaining needs. The availability of surface water controlled by the dams enables the impact of droughts to be contained.

An already perceptible climate change...

Casablanca and Rabat have experienced **warming for the last five decades**. On an annual level, the average temperature, for the 1962-2008 period has risen and shown an increase of 0.3℃ per decade in Casablanca and 0.2℃ per decade in Rabat. In pluviometric terms, both Moroccan cities show a clear decreasing tendency in annual rainfall accumulation; i.e. approximately 2.8mm/year.

The future projections for the year 2030, evaluated using dynamic downscaling models for several greenhouse gas emission development scenarios, foresee a warming up of 0.8 to 1.3℃ at the annual scale for Casablanca, accompanied by a slight increase in the number of summer heat wave days. Annual rainfall accumulation is assumed to decrease by 6 to 20%, and by 15 to 35% in winter. The planned changes for Rabat are of the same dimension.

The daily extremes (maximum rainfall over 24h) do not change in the same way for all the models/scenarios. Uncertainty remains as much for the amplitude as the return period. For maximum daily rainfall for a return period of 10 years, the variation forecasts, between the current and future (2030) scenarios, vary between –30% et +27% depending on the models. This variability becomes even more accentuated for a return period of 50 years. By default, it has been decided within the framework of this study to consider the results of the most pessimistic model/scenario, i.e. CNRM_A1B, if only as a precaution.

… which may further aggravate natural risks

Apart from the geological (instability of natural ground) and seismic risks, other natural risks will be affected by climate change.

Coastal erosion and submersion will be particularly affected by the **sea level rise** indirectly provoked by global warming through the thermal expansion of water masses (dilation) and the melting of the polar ice caps. On the basis of a critical analysis of the IPCC forecasts and the latest bibliographic references on the subject, we consider for this study an **overall sea level rise of 20cm by the year 2030**. It should be noted that this is a high hypothesis and it is impossible to have an accurate reading of the Moroccan Atlantic coast in the absence of tidal data over a long period.

In spite of a number of coastal protection projects, **the sea level rise is going to reactivate or increase the coastal erosion process** and therefore the coastline will retreat. The sandy beaches still in a natural state face the risk of **retreating by an average of 10 to 15m** by the year 2030. In the urbanised sectors, the walls built to protect the residential areas will enhance the coastal retreating process and will face major damage (undermining at the bottom of the walls). **In the case of storms combined with a high sea level** (a value of +2.85m NGM taken into consideration for the Bouregreg, and +3m NGM for Casablanca), the development works at the top of the beach in the urbanised areas will face the risk of **severe damage** as the width of the beach is insufficient to withstand the swell impact being too close to the sea. The sandy beaches still in a natural state will be totally immersed and should manifest a significant amount of retreat. However, they should be able to partially reconstruct during the good weather and almost entirely when the upper beach is formed by dunes.

In the Casablanca region, the coastal stretch exposed to a high risk of erosion or submersion will remain approximately identical to the present situation, which is around 40km of coastline. The sea level rise will however slightly increase the **risk of submersion of low-lying areas**, especially around the outlets of the main wadis Mehla and Nfifich (+140 ha of submerged area for a 50-year flood). On the other hand, at the mouth of the Bouregreg Valley, the breakwater construction project should be in a position to reduce the negative impact of sea level rise associated with strong swells. Beach erosion will continue, however, at a slower pace.

As regards the **river flooding or runoff risk** in Casablanca, the climate changes taken into account by “Maroc Météo” (Moroccan meteorological department) between 1960 and 2004 have already shown an increase of 20% in the decennial flow rates. The objective of protection considered in the new sewerage master plan currently under way is 10 years, based on revaluated intensity-duration-frequency curves.

The development of the “Super Collecteur Ouest” (western mega drainage system) will enable the flood waters from the **Bouskoura wadi** to be diverted. The project is designed for a return period of 20 years and the drainage system will also receive the runoff from several existing catchment areas or from areas being urbanised. For these catchment areas, the “Super Collecteur Ouest” will drain the projected flow rates corresponding to a return period of 10 years. The effect of the sea level rise should not significantly disturb the functioning of this main water drainage system given the relatively important slope of the structure (0.7%). Climate change could however lead to an increase in the flood water flow rates of 15%, which would reduce the protection level roughly from 20 to 15 years. However, there is a high degree of uncertainty regarding the wadi’s flow rate estimate and particular attention should be paid to the behaviour of the drainage system during exceptional events which exceed the design flood.

The planned development works, in particular the dams on the **El Maleh wadi** and its tributaries, aim to reduce the flood water flow rates at the entrance of the city of Mohammedia. The climate change impact could lead to an increase in flood water flow rates by 15%, excluding the impact of the dams. This impact would only be visible downstream during the 100-year flood, due to the high impact of the dams on lower-degree flooding compared to the 100-year flood (the floods will, in particular, be fully tempered by the Boukerkour Dam until a return period of 100 years; this dam controls approx. half of the catchment area). The downstream development works enable sea water evacuation to be improved and the most vulnerable sectors to be protected. The sea level rise effect remains to be analysed as the available information does not suffice to assess it more accurately.

With regard to the **Chaouia Plain**, upstream from Casablanca, the development and urbanisation of the catchment areas require particular surveillance. In fact, the flood waters of these catchment areas currently spread out and infiltrate the Berrechid Plain which constitutes a vast area of surface spreading. The flood waters particularly help to recharge the ground water. The risk of flooding the areas situated downstream from the Berrechid Plain during heavy flooding cannot be put aside given the urban development and the concentration of runoff which will be necessarily associated with it.

The projected urban development in the valley of the **Bouregreg wadi** foresees a localised protection for areas to be kept out of water during the 100-year flood (dikes), reference flood of the development project. Keeping 370 hectares of urban area out of water, planned in sequence 3 upstream from the ONCF railway line, leads to a maximum rise of water level in the downstream sector of 35cm (results obtained from the 2D model realised during the project’s complementary studies). The hypotheses associated with climate change could lead to an increase of 17% in the peak flow rate of the 100-year flood downstream from the SMBA Dam. This increase would lead to the raising of water levels in the Bouregreg wadi floodable area ranging between +35cm downstream from the Moulay Hassan Bridge, and between +20 and +30cm in the sector between the ONCF Bridge and the bypass. The combination of these two impacts would lead to a water level rise of roughly 65cm upstream from the urban area. These levels need to be taken into consideration for the definition of protection structures and the analysis of variants. The development project includes the realisation of two water bodies whose oscillating volumes, in accordance with tidal cycles, should allow sufficient speed in the channels to be maintained in order to ensure minimum water levels. Variants of the project are being analysed in order to attain the desired objective. The effect of a sea level rise by 20cm at the mouth rapidly gets weaker towards the upstream level for the 100-year flood: it is only 5cm at 850 meters upstream. This rise in sea water level may, though, have an impact on the flowing speed of navigational channels at times not during the flooding period.

Lastly, with regard to **water resource management**, the change in the demand pattern in Greater Casablanca should increase by 1.7% excluding major projects and by 1.9% per year including major projects. These figures are based on achieving a distribution network yield of up to 80%, which is currently 72%, and on a relative stagnation of unitary consumptions. There will be a significant climate change impact on the availability of the Bouregreg (SMBA) Dam's resource as average supply could reduce by 30%, or even up to 40%. The available information is insufficient for a more detailed assessment of need-resource allocation for Greater Casablanca which needs to take into account the changing pattern of needs for the entire area supplied by the SMBA Dam as well as a possible change in provision of the Oum Er Rabia by 120 Mm^3 per year. This provision would represent half of the water demand of Greater Casablanca for the year 2030. The Bouregreg Valley urban development project will contribute towards increasing pressure on water resources.

Emergence of new vulnerable areas by 2030

The population of Greater Casablanca is **3,325,000 inhabitants** in urban areas and 305,000 in rural areas. It has increased by 504,000 during the intercensal period of 1994-2004, maintaining a sustained increase, even if it appears to be a little less compared to the previous period. This regular increase in volume since 1994 translates into, on the other hand, an **average annual rate of constant decline** (+1.5% on average per year between 1994 and 2004, compared to +2.0% per year from 1982 to 1994).

It should be pointed out that there has been a rapid two-fold increase in the number of households compared to the population itself which leads to **very high urban pressure**. In fact, an urban increase of 700 ha to 1,000 ha per year is currently being observed. However, this urbanisation has changed shape. For a long time situated in the immediate extension of the conurbation, and mainly produced by public operations, it has progressively developed "beyond the walls" of the city, taking various forms which more or less comply with the rules of urban development

At present, the **main vulnerable areas** facing natural risks in the Casablanca region are:

- Dense residential areas built with poor quality materials (medina, kasbah, precarious housing areas, poor quality post-war urban housing units, etc.). The seismic hazard, however, is deemed to be sufficiently low so the risks are negligible.
- As regards erosion and marine submersion risks, the vulnerable areas are mainly limited to the urbanised seafront bordering the beach between Casablanca and Mohammedia. It should be recalled that tsunami risks, assessed within the framework of this study, are similar to those of the storm surge caused by a 50-year storm.
- Regarding flood risks, the at-risk sectors are relatively dispersed and either they have inadequate or badly-equipped storm water drainage systems. Since the hydraulic

development of the El Maleh wadi, floods are mainly concentrated in the urban section of the Bouskoura wadi basin.

The SDAU (development and urban planning master plan) hypothetically calculates the population to be 5.1 million inhabitants in 2030, corresponding to an annual growth rate of 1.3%. The housing requirements which result from demographic forecasts will be considerable. In order to meet such requirements, resulting only from the increased number of households, it will be necessary to build between 24,000 and 28,000 housing units on average per year. The recommended development works consist in managing the Centre-City (Casablanca) growth and organising the reception of most of the demographic and economic growth in the outskirts rather than "oil patch" spreading of the city centre.

With the reduction in unhealthy living quarters, the tendency to reduce urban density, and the improvement of the quality of construction material, there should be a reduction in vulnerability to seismic risks, even if, with demographic growth, a greater part of the population will be exposed to such risks. On the other hand, the **urban strengthening project and the development of major projects all along the coastline** may create a conflict of use and contradict the preventive and protection measures linked to climate change, especially in terms of erosion, tsunamis and sea level rise. These risks are even more pronounced in a few sensitive sites such as the SAMIR refinery and the Mohammedia port and industrial area. It should be noted that these sensitive sites are also situated at the mouth of the El Maleh wadi, and hence are under threat of exceptional river flooding (beyond the 100-year flood frequency). In urban areas, in spite of a possible 15 to 20% increase in flood water flow rates, the storm water drainage programmes and particularly the western mega drainage system project of the Bouskoura wadi should significantly improve the situation. This, however, assumes taking the non-aggravation constraints of flow rates downstream into consideration in urban development planning and land occupancy management of floodable areas.

As regards the **Bouregreg site,** there is little vulnerability at present, the valley being used as a land reserve within the framework of a vast urban development programme. The first part of this programme, at the mouth of the river, is being completed. In the future, the valley will undergo significant changes even if the urban sectors are only going to represent 8% of the total surface area of the perimeter. The urban density in these sectors will be rather high to very high (137,600 inhabitants are expected and 88,200 jobs), on a site largely exposed to natural risks: flooding from the Bouregreg, marine submersion, ground instability, and the risk of earthquakes. The development programme needs to carefully integrate such constraints which will generate non-negligible additional costs.

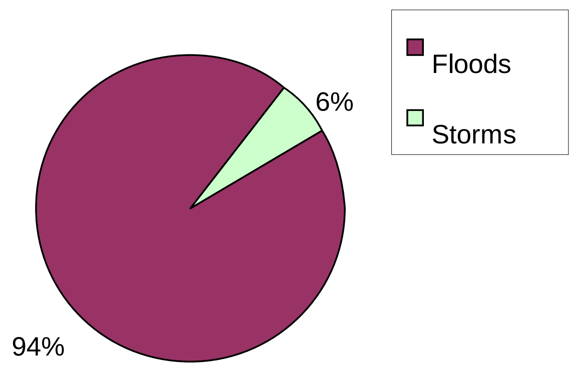
Damage that can be assessed

A **preliminary approach** to the cost of natural disasters and climate change for the year 2030 has been proposed. It includes damage relating to earthquakes, flooding, storms (coastal erosion and marine submersion), and the reduction of water resources. The direct (damage) and indirect costs (economic loss relating to the event) are distinguished. The results are expressed in average annual costs.

The total amount of annual costs pertaining to disasters considered in this study, taking into account the climate change factor, is estimated to be **1,162 MDH** for the year 2030, expressed in current Dirhams. This represents **222 DH/person/year,** i.e. **0.26% of the GDP** of Casablanca and the Bouregreg Valley for the same target year (2030). **Uncertainty is high** and estimated to be 0.3% of GDP, i.e. a bracket of **0.1% and 0.4% of GDP.**

No longer expressed on an annual basis but on a scale of the period considered, the **present net value of disasters considered for the period 2010-2030 is approx. 11 billion DH**, in constant 2010 terms, which represents **around 7% of the GDP of Greater Casablanca** (at present).

The indirect costs represent about 20% of total expenditure. The majority of costs are due to **floods**. Moreover, the **portion attributable to climate change is considered to be insignificant**.



The case of **the impact on health** is a little particular: in this case, the calculated costs only represent the portion attributable to climate change, whereas for the other risks, it is an overall cost that is presented, which takes climate change into account, amongst other factors. It is therefore safer to break down this non-homogeneous data. The average yearly costs **are around 521 MDH for Casablanca and 8.9 MDH for the Bouregreg valley, representing roughly 0.12% of the area's total GDP.** Health-related issues therefore have a significant impact on the overall structure of the costs of the different risks presented in this study.

It should nevertheless be recalled that the **exercise is rather difficult** and the economic calculations remain largely replete with uncertainties.

An improving institutional framework

Regarding natural risk management, examining documents helps to observe that **Morocco has clearly taken due care to adapt its regulatory body to its objectives**. Following the restructuring of the "Direction Générale de la Protection Civile" (general directorate for civil protection) carried out between February and March 2009, the management of emergency situations has changed. As per the opinion of the stakeholders interviewed, the new protection mechanism and in particular, the "Comité de Veille et de Coordination" (supervision and coordination committee) seem to be satisfactory.

This element of satisfaction is particularly derived from the **recently obtained results** in terms of preparedness (decentralised storage of materials by the "Protection Civile" (civil protection)), forecast (meteorological warnings announced by "Maroc Météo") and organised response to **torrential rain and subsequent flooding occurring between December 2009 and March 2010.** A significant amount of effort seems to have been made to ensure the improvement, modernisation and better functioning of the surveillance and warning systems.

In organisational terms, it should be noted that **removing the inter-ministerial overlaps** of skills at the national level left a relatively simplified structure, with a coordination framework functioning rather smoothly. This shows the advantage of separating the role of high command levels, ensuring a Communication-Command-Control structure, from the technical role of the Fire Department.

Vulnerabilities and Risks in Casablanca - Synthesis Table

Hazard	Time Horizon	Urban Sensitive Components	Risk			
			Type (casualties excluded)	Location	Intensity	Level
Ground instability / seismicity	2010	Dense residential districts built with poor quality materials: medina, Kasbah, insecure housing, deteriorated post-war urban housing, etc.	Risk of structural damage and collapses in the case of an earthquake.	See Figure 70	No or very little damage (intensity ranging form IV to IV-V for a return period of 50 years).	Very low
	2030	Same components, but a reduced surface area due to slum clearance, the tendency to reduce urban density and the improvement in the quality of construction materials.		Same as Figure 70, minus the insecure housing (slum settlements).	Same intensity.	Very low
Marine submersion / tsunami	2010	Natural coastline outside of the conurbation and dense urban areas along the seafront.	Structural damage to buildings situated at the front; submersion of low areas.	See Figures 71-72 (submersion).	50km of coastline considered to be at a high risk of submersion (approx. 1,200 ha exposed to a risk of submersion for a storm with a frequency of 50 years). Risk of a tsunami comparable to the storm surge.	Medium
	2030	Same components, but increasing urbanisation along the seafront within the framework of major projects (Aïn Sebaa, Port, Marina, Avenue Royale, Nouvelle Corniche, El Ank, Sidi Abderrahmane, etc.).		See Figure 71-72 (submersion).	Same linear of coastline concerned by high risk of submersion (increase of roughly 12% of surface area potentially exposed to a risk of submersion for a storm with a frequency of 50 years).	Medium
Marine erosion	2010	Natural coastline outside of the conurbation and dense urban areas along the seafront.	Beaches destruction and structural damage to buildings situated at the front (erosion).	See Figure 27	42km of coastline considered to be at a high risk of erosion.	High
	2030	Same components, but increasing urbanisation along the seafront within the framework of major projects (Aïn Sebaa, Port, Marina, Avenue Royale, Nouvelle Corniche, El Ank, Sidi Abderrahmane, etc.).		See Figure 53	Same linear of coastline concerned by high risk of erosion	High
Flooding	2010	Dense residential districts along the former Bouskoura riverbed in Casablanca; dense residential districts and industrial-port area of Mohammedia at the opening of the El Maleh wadi.	Flooding of ground floors (damage to buildings).	See Figure 73 for overall view and Figures 74 to 75 for detailed views.	Approx. 5,500 ha of land flooded by the 100-year flood all over Greater Casablanca. Ten hot spots corresponding to the overflowing of the primary network for rainfall with a return period lower than ten years.	High
	2030	Same components, also with major development and urban planning projects (heart of the city and Anfa in Casablanca; strengthening the industrial and logistics centre, business centres and major facilities in Mohammedia).		Cannot be located without a hydraulic model.	In Casablanca, despite a possible increase by 15 to 20% of flood flow rates, the storm water drainage programmes and, in particular, the western super-collector should improve the situation. Two new dams on the El Maleh wadi should also reduce the risk of flooding in Mohammedia.	High
Water scarcity	2010	Population and economic activities (water needs).	Water shortage.	Cannot be mapped.	Water supply from two major dams (SMBA and El Massira). No restriction of use in the dry season for the last few years.	Low
	2030	Same components, but increase in needs (+32% for drinking water) between now and the year 2030.			Increase in the supply capacity from the Bouregreg dam (SMBA), the height of which was recently raised, and is deemed sufficient to meet needs for the year 2030. Climate change (not taken into account in the national forecasts) could, nevertheless, bring about a reduction in the regularisable volumes by roughly 30 to 40%.	Medium

Vulnerabilities and Risks in Bouregreg Valley - Synthesis Table

Hazard	Time Horizon	Urban Sensitive Components	Risk			
			Type (casualties excluded)	Location	Intensity	Level
Ground instability / seismicity	Before starting the urban development program	Several douars spread out in the valley (poor quality rural housing). *N.B.* the Oudayas Kasbah and the Rabat and Salé medinas are also highly sensitive to earthquakes, but are considered to be outside the study area.	Risk of structural damage and collapses in the case of an earthquake.	See Figure 40 (current situation).	Very little to little damages (intensity ranging from V to V-VI for a return period of 50 years	Low
	2030	Same components. The valley's urban planning programme, based on high standing buildings, is assessed as not being very sensitive to this risk.		See Figure 40 (2030 situation).	Same intensity, but increased exposure to risks	Medium
Marine submersion / tsunami	Before starting the urban development program	Sandy beaches at the mouth of the Bouregreg.	Structural damage to buildings situated at the front; submersion of low areas.	See Figures 15 and 40 (submersion).	The Rabat and Salé beaches are at a high risk of submersion for a storm with a frequency of 50 years. The total submerged surface area for this event is approx. 860 ha, mainly situated in the central area of the valley, but no construction in this sector. Risk of tsunami comparable to the storm surge.	Medium
	2030	Same situation, but urbanisation at the top of the beach; new dense residential districts built at the bottom of the valley.		See Figures 33 and 40 (submersion).	Reduction in the risk of submersion at the mouth of the Bouregreg due to the construction of a new breakwater, but increase by roughly 16% of the surface area potentially exposed to a risk of submersion for a storm with a frequency of 50 years (potential impact on the development of sequence 3 of the urban planning programme).	High
Marine erosion	Before starting the development program	Sandy beaches at the mouth of the Bouregreg.	Beaches destruction and structural damage to buildings situated at the front	See Figure 14	The Rabat and Salé beaches are at high risk of erosion for a storm with a frequency of 50 years	Low
	2030	Same situation, but urbanisation at the top of the beach; new dense residential districts built at the bottom of the valley.		See Figure 32	Reduction in the risk of erosion at the mouth of the Bouregreg due to the construction of a new breakwater	Medium
Flooding	Before starting the development program	Several douars spread out in the valley; several facilities and commercial activities towards the river mouth; road and railway links to Rabat-Salé.	Flooding of ground floors (damage to buildings).	See Figure 40 (current situation).	Approx. 1,800 ha of land flooded by the 100-year flood. Douars outside of the floodable area, but majority of industrial or commercial activities are in potentially floodable areas.	Low
	2030	Suppression of some existing facilities and activities; construction of new dense residential districts at the bottom of the valley; strengthening of existing links and creation of a tramway line.		See Figure 40 (2030 situation). N.B. without a model, coverage of the floodable area corresponds to the current situation.	Rise in water levels during the 100-year flood, ranging from +35cm downstream from the Moulay Hassan Bridge, between +20 and +30cm in the sector between the ONCF Bridge and the bypass. Approx. 100,000 people (inhabitants + employees) potentially exposed to the river flooding.	Very high
Water scarcity	Before starting the program	Population and economic activities (water needs).	Water shortage.	Cannot be mapped.	Water supply from the SMBA dam. No restriction of use in the dry season for the last few years.	Low
	2030	Same components, but increase in needs (for a new “city” with roughly 140,000 inhabitants and 90,000 jobs) between now and the year 2030.			Height of the Bouregreg Dam (SMBA) recently raised + Boukhmiss Dam and water transfer from the Sevou basin projects judged to be sufficient to meet needs. Climate change could, nevertheless, bring about a reduction in the regularisable volumes by roughly 30 to 40%.	Medium