pruning techniques to reduce alternate bearing between years; the nutritional value and the carrying capacity of different types of rangeland at different climatic conditions; and monitoring of meat and milk productivity of small ruminants according to the animal pedigree, type of rangeland and climatic conditions.

Infrastructure measures

Public institutions should rehabilitate their infrastructure to address operational inefficiencies (quarantines, laboratories, frontier posts, etc). Infrastructure related to the agriculture sector, which mostly occurs at farm level, includes water harvesting and distribution systems (dams, hill lakes, reservoirs and channels), terraces, greenhouses, agricultural machinery, agro-processing plants, storage and packaging units, hives, farm constructions, etc. The Green Plan at MoA, which is the mandated authority to provide such services to farmers on a demand-driven basis, should be reinforced.

An adaptation action plan for the agriculture sector is proposed in Table 4-5.

4.3.4 Cost of adaptation

The cost of adaptation at farm level would be impossible to address since measures are not limited in time, and the number of exploitations and actors involved are tremendous and heterogeneous. Some measures (such as changing planting dates, shifting varieties, no-tillage, crop diversification) are costless and comprise mainly operations that do not necessarily pose an additional cost to farmers. Other measures require additional investments such as irrigation systems, new rootstocks, adapted greenhouses and farm infrastructures, adapted machinery for seeding, weed control and harvesting in no-tillage systems, etc. The costs of these inputs, with the necessary labor needs are unpredictable because they depend on the scale of investments and baseline conditions at the farm level. However some of these measures are already being implemented regardless of climate change, to improve yields and product quality, or to decrease the cost of production.

The cost of adaptation at the level of public institutions, notably education, research and assistance, public infrastructure and institutional measures, is seen as an integral part of the national agriculture strategy. The budget line of adaptation is thus already included within the strategy, which means that only additional budgetary requirements should be addressed.

4.4 Vulnerability and Adaptation of the Electricity Sector

Although Lebanon figures among the countries with high coverage of electric power in the region (IEA, 2006), self-generation still plays a large role in electricity supply and demand due to the inability of EDL to meet demand effectively (World Bank, 2008). Expected changes in weather pattern due to climate change are only expected to exacerbate the already existing problems affecting the electricity sector in Lebanon.

4.4.1 Methodology

Scope of Assessment

The main aspects of vulnerability of the electricity sector focuses on 1) the increased pressure on the energy production system as a result of increased cooling demand during summer, increase in oil/gas prices and potential disruption of hydroelectric power plants as a result of reduced precipitation and 2) the increased pressure on the power supply chain as a result of increased demand, and possibly storm surges.

The assessment covers the entire country during summer and winter, since cooling and heating demands, hydropower generation, and power supply cover the whole territory and all seasons. The year 2004 is used as the baseline year and the analysis extends until 2030.

Methods of Assessment

The expected increase in temperature estimated by the climate model is used to calculate the increased energy demand in summer. Assuming an average Coefficient of Performance (COP) of 2.8, an average outside temperature between 13.6°C for January to 28.7°C for August (MoPWT, 1971) and an inside temperature of 22°C, an increase of 1 to 3°C in temperature by 2040 is estimated to lead to an annual increase in electrical cooling consumption of 9.04% to 28.55%. No projections are made for the 5°C increase in temperature by 2080-2098 since it is difficult to predict energy demand by then.

The increase in demand from natural and economic growth from 2004 to 2030 is estimated using expert judgment in the absence of data on activity level, energy intensity, etc. to make a disaggregated end-use oriented demand analysis and projections using LEAP. The additional growth in energy consumption resulting from increased cooling demand in summer is calculated for 2004 to 2030 and superimposed on the business-as-

Table 4-5 Adaptation action plan for the agriculture sector

Impact	Proposed Adaptation Strategy	Activities
Reduction of water availability for irrigation	Shifting from surface to drip irrigation	Survey on water sources Topology-hydrology-water needs study Design of irrigation schemes Installation of systems Training for farmers
Increase in pest outbreaks	Adopting Integrated Pest Management (IPM) or organic farming	Assess the cropping pattern of the concerned areas, define the key pests and diseases that are a major problem Define the number of traps, pheromones to be distributed as well as the closest meteorological station to be linked to import the required material Distribute the necessary material (traps, pheromones, etc.) Training for farmers and installation of material
Chilling requirements not met for some cultivars at specific locations, and rootstocks not tolerating drought	Renovating orchards with low chilling requiring cultivars grafted on drought tolerant rootstocks	Survey on cropping pattern (cultivar/ rootstock) per altitude Identify vulnerable orchards and quantify trees to be replaced Propose a plan of orchard renovation with adapted cultivars and rootstocks Renovate orchards with a rate of 20% of trees over 5 years Training farmers on new plantations management
Increase in water demand in annual plants with low tolerance to higher temperatures	Shifting in planting date Shifting to adapted cultivars Shifting to conservation agriculture	Conduct trials for new cultivars and plantation systems Conservation agriculture for potato, cereals and tomato Disseminate results to engineers (public/private) Propose Good Agricultural Practices to concerned farmers Import necessary plant material and equipment Select appropriate cultivation dates for each crop Develop a system to alert farmers on the occurrence of extreme weather events (early hail, frost, etc.)

usual scenario. These estimates are entered in LEAP just to draw a curve on the growth in consumption under the baseline scenario and the two warming scenarios (+1°C and +3°C). Data gaps related to energy consumption on household equipments, sectoral breakdown of demand and consumption figures, demand, supply, capacity and efficiency of power plants, and proportion of electricity self-generation prevented the use of LEAP in conducting a disaggregated end-use oriented demand analysis with projections. Assumptions based on expert judgment are used when necessary.

Moreover, the expected decline in precipitation levels was taken into consideration to assess the potential impact on hydropower given the government plan to build over 20 dams and hydropower plants along major rivers. Finally, the assessment of the sector's overall vulnerability land impact is based on the baseline socio-economic scenarios (A and B) and the climate change scenario.

Development of the sector under socio-economic scenarios

The NPMPLT projections put Lebanon's energy demand in 2030 at 4,200 MW, based on a 3% in consumption per capita by 2015 and a 1% increase by 2030, which was planned to be met through the addition of 3,000 MW by 2030 (CDR, 2005). However, current projections give a higher estimate of increase in demand, and recent government plans consider the rehabilitation of the Zouk and Jiyeh plants rather than their retirement. Therefore, a 4-5% yearly increase in demand was assumed until 2020, followed by a 2-3% increase from 2020 until 2030, knowing that in middle income countries, demand for electricity grows at a factor above the GDP growth, as reported by the World Bank (2008). Based on a peak load of 2,575 MW in 2004 including self-generation, these rates yield a projected demand of around 4,820-7,555 MW by 2030. These figures are in line with the World Bank's projection of demand by 2015 of 4,000 MW, necessitating an additional 1,500 MW from EDL and self-generation by that date (World Bank, 2008). In terms of energy consumption, projections using the same growth rates give a range of 25,530 - 40,000 GWh by 2030, based on 13,631 GWh in 2004.

Under Scenario A, the power sector and energy security will not really be at a disadvantage since the scenario estimates a slow increase in energy consumption and total demand, a limited need for the expansion of the distribution network and a higher interest in renewable energy sources.

However, under Scenario B, high population and GDP growth combined with higher standards of living will have a double edge impact on energy consumption and total energy demand, which are expected to increase considerably. Additionally, the increase in urbanized area will put additional pressure on the power distribution system that will require expansion. In spite of the relative affluence and more balanced economic development that will enable EDL to cope with this increase in demand, energy security will still be threatened.

Successive governments have suggested numerous master plans for the electricity sector throughout the years. However, none of these plans and strategies has been implemented so far. The current government proposed in June 2010 a policy paper for ensuring 24-hour supply, improving security and reducing costs and losses in the electricity sector by 2014. The proposed plan tackles the addition of generation capacity to cover the existing gap, the required reserve margin, as well as the necessary improvement in transmission and distribution infrastructure (MoEW, 2010).

4.4.2 Vulnerability and Impact Assessment

Energy demand and consumption

Electricity demand is sensitive to fluctuations in ambient temperature, decrease on precipitation and increases in oil prices. The overall vulnerability of the electricity sector is estimated to be moderate to high due to increase in energy demand, power production and supply chain. The forecasted rise in ambient temperatures coupled with a natural growth in population and consumption rates, would lead to higher cooling demand in summer, pushing the peak load up. This would in turn put pressure on the power production and supply system to meet the additional increase in demand and consequently drive the cost of power production up. In addition, the adaptive capacity of the power sector is generally low as a result of the already existing shortages and rationing, the slow expansion in power generation capacity and the deficit in EDL's budget. Figure 4-14 shows the increase in energy consumption (GWh) for the period 2004 - 2030 based on 3 scenarios.

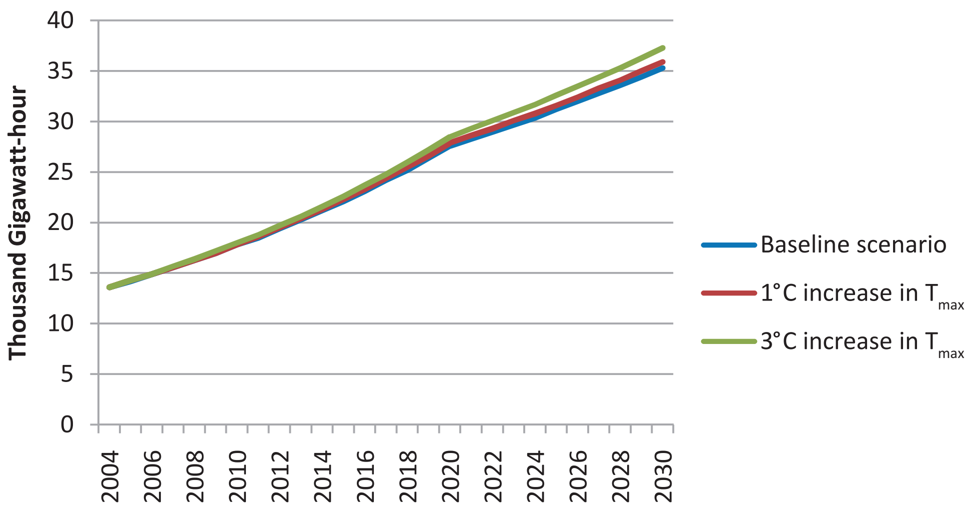

Figure 4-14 Forecasted increase in energy consumption resulting from a 1°C to 3°C increase in ambient temperature

The 1-3°C increase will incur an additional 635 GWh to 2,047 GWh on energy consumption. Given that cooling consumption constitutes 20% of total energy consumption, and that temperature increases of 1°C to 3°C lead to 9.04% and 28.55% increase in cooling consumption respectively, the increase in total consumption from increased cooling consumption will be 1.8% for a 1°C increase in temperature, and 5.8% for a 3°C increase in temperature. This will consequently necessitates an expansion of installed capacity between 87 and 438 MW, based on a forecasted demand of around 4,820-7,555 MW by 2030. The demand increase will surely be higher under Scenario B with the high population growth and improvement in standards of living that will bring about an increase in per capita energy consumption regardless of climate change. On the other hand, the global increase in energy demand, coupled with the gradual depletion of oil reserves, is expected to lead to an increase in oil prices, which will drive the cost of energy production higher.

Hydropower generation

The forecasted 10 to 20% decrease in precipitation by 2040, together with the increase in temperature, leading to higher ETP, will eventually lead to a decrease in river flows, which will decrease the hydropower generation potential. The availability of hydropower plants is also expected to decrease given the forecasted shortening of the winter season and the increase in the length of drought periods. By the end of the century, with more severe reduction in precipitation, hydropower generation potential will drop further, which would jeopardize the government's plans to increase energy capacity.

Renewable energy

The predicted insignificant changes in wind speed and cloud cover are not likely to lead to any potential change in solar and wind energy, thus making renewable energy sources slightly vulnerable to climate change. The governmental plans to invest in wind energy might not be affected and the potential for solar energy might be positively affected, especially inland, where a 5% decrease in cloud cover is forecasted by the end of the century.

4.4.3 Adaptation Measures

Efforts of the power sector to adapt to the potential adverse impacts of climate change converge and complement mitigation measures that entail ensuring a 24-hour supply of electricity, reducing budget deficit, reducing dependence on exported oil consumption as well as accounting for the expected additional generation capacity needed to meet the increasing cooling demand. Therefore, adaptation efforts should mainly be directed at implementing the Policy Paper for the Electricity sector (MoEW, 2010), in addition to the application of the thermal standards for buildings proposed by DGUP (MoPWT et al., 2005).

4.5 Vulnerability and Adaptation of the Water Sector

Lebanon faces significant challenges in meeting the country's water demand in terms of quantity and quality. Unsustainable water management practices, environmental risks and water governance shortcomings are among the main obstacles facing the sector (MED EUWI, 2009). Extensive aquifer over-abstraction and years of mismanagement have contributed to causing the hydraulic gradient to reverse, encouraging seawater encroachment in coastal areas in Lebanon. This has been further exacerbated by the continuous urban growth and repeated natural drought conditions.

4.5.1 Methodology

Scope of Assessment

The water sector is the hardest sector to assess due to the lack of data such as non-consistent measurement of river flows, lack of metering systems to measure withdrawals from each sector, etc. and the significant amount of losses resulting from leakages and widespread unlicensed wells where pumping is not monitored.

This assessment looks at the combined effect of precipitation and temperature variation on evapotranspiration, and consequently on the reduction of water availability throughout the country. To that is added the effect of population and economic growth. Potential impacts of temperature increases on snow cover are also addressed based on existing studies as a result of limited relevant data and measurements in Lebanon.

The study area extends from Hadath in the South-West to the Cedars in the North East, spreading over an area of 2,500 km^2. This area comprises most of lebanon's topographic features as well as the Jurassic aquifers of Kesrwan, the totality of the Kneisseh and Hadath Cennomanian aquifers, the majority of Chekka springs recharge area, the majority of Berdawni spring recharge area, as well as four major catchment areas (Beirut