

## LAND-USE/COVER CHANGE, WATER RESOURCES AND DRIVING FORCES DURING 40 YEARS IN LEBANON

**L**and cover change that has overtaken the Lebanese territory in the second half of the twentieth century is mostly expressed by chaotic urban expansion at the expense of agriculture, forestry and natural resources. The 1960's agro-statistics still are the basic reference for evaluating any change, and this persisted until the 1980's where the areal extent of agro-lands was estimated at 260000 ha while forestry stood at 70000 ha. The drastic crisis events from 1975 to 1990 in the country led to lack of official control, and an increasing abuse of laws, lands and forestry by various communities. Add to this the Israeli persistent military actions and occupation of southern Lebanon, that resulted in huge agro and natural cover damage and land deterioration.

Obviously, the above meant a loosening of control on using water, monitoring its resources, and its mismanagement. Both urban and rural communities had to face water problems in quantity and quality. Together with the increasing natural stress on water due to climate clearly pointing out to reduced supplies, human interference contributed to a vicious cycle of water unavailability, excessive use, and further land degradation. This is becoming more acute as agriculture consumes close to 70% of total water in the country.

Change detection studies relied on comparing the agro-map of the 1960's with a land cover map produced in 1990. Relevant data, together with administrative boundaries and the 1999 agro-statistics, were introduced in a GIS system for manipulation. The study shows clearly that there is an overall reduction in agro-production varying from 31% in olives, 32.5% in forestry, 35% in citrus, 72% in fruit trees, and 82% in vineyards. The proportions vary among the different provinces influenced by several socio-economic factors. These include closeness (or being far away) to center of control, with stricter application of regulations, economic status especially in the poor agro-sector and literacy stand. Thus, in Beka'a, where most agriculture occurs, the largest land degradation and forest cover removal have taken place.

The rates of change in certain areas, and the abuse of natural resources including forestry and water, are becoming alarming. Climate change and environmental aspects are definitely contributing to degradation, but it is more the human interference and socio-economic stability that is a more powerful driving force.

### HISTORICAL PERSPECTIVES

Lebanon witnessed dramatic changes in its population dynamics, construction growth and agriculture. This took place mostly post 1960's and was accompanied with an acute migration from rural into urban areas, with consequential negative impacts in both environments especially land degradation in the former and excessive demand on water in the latter. Beirut, the capital, experienced this most notably growing from a population of about 450000 in the 1960's to become currently close to two million.

These changes, plus a change in life style, more towards consumerism, meant a deep impact on land use and resources. Statistical information from the Ministry of Agriculture show now that agricultural surfaces occupy 261100 ha, among them cereal 20%, fruit trees 23%, olive 20%, legumes 17%, others 20%. Other sources of information are agricultural maps in 1963 and the land cover map of 1990. The forest occupies 1357.5 km<sup>2</sup>, and rangeland occupies 3471 km<sup>2</sup>, and the rest are urban areas or barren rocky terrain. The land, which used to be valued for its agricultural, natural or scenic aspects, has been converted into a supply-demand real estate commodity controlled by market prices within urban environs. Nevertheless, the agricultural sector progressed considerably from the 1950's onward, and satisfied 73% of the local market needs in the early 1970's (MoA, 1986). This growth was unfortunately checked as the uncontrolled liberal policies did not gear into an organized and a properly functioning sector. There was no agricultural scheduling, no programming, no protection against foreign produce and no well-structured securing of the market. The high cost of working the land in mountainous areas made its rural community most vulnerable. Expectedly, this led to abandoning the mountainous farms, notably grapes, olives and apples that constituted the backbone of agro-economy then.

## STATISTICAL OVERVIEW

### Previous stand

Baseline agro-statistics go back to the 1960's, advantaged then with a land survey coverage by aerial photography and physical mapping: aerial photos at 1:25000 (1962), geology at 1:50000 (1950's to 1960's), topography with basic cover at 1:20000 (1960), agriculture and forestry at 1:200000 (1960 and updated 1980). Most of these maps were recently used and digitized at the Lebanese National Center for Remote Sensing in order to avail them digitally as base historical information and, therefore, to allow to study "change detection" by comparing their coverage with the recent status. This is especially significant in view of serial information that can be supplied through different time intervals by remote sensing imageries.

Several important "covers" (land cover, land use ... etc.) were produced recently after some programs used satellite imageries for mapping. These include the land use map of Greater Beirut (IAURIF, 1987), the land cover maps of all Lebanon at 1:50000 (FAO, 1990), and more recently land use maps of the whole coastal stretch (10 km wide ribbon) (ECODIT, 1996) and that of southern Lebanon (IAURIF, 1999). The significance of the 60's baseline data is in their use as a reference to types of agriculture, green cover and land exploitation. That gives an idea of how well, or how bad, was the land use or practices and, to a certain extent, what major components used up water. The effects of increasing activities of agriculture and grazing on water is reflected in the increasing demand for irrigation of about 155% in almost 40 years, and an increase of cattle between 36% to 160% the last 20 years. What accentuates the problem is that water availability inland, where the mentioned activities are concentrated, is rather low as it is a semi-arid area. Overall, the water table is going deeper and the near-surficial water is becoming polluted especially with agro-chemicals plus others. Table 1 reflects on land use data immediately noticing the largest portion of rocky uncultivated land at 52% followed by arable land at 25%.

Land use/Cover	Hectares	Percentage
Arable land	260000	25
Forest, with cover of at least 10%	70000	7
Forest, sparse (less than 10% cover)	65000	6
Abandoned lands, mostly old terraces	70000	7
Rocky, non-cultivated lands, degraded range lands	515000	52
Urban and constructed areas	27000	3
Total area	1017000	100

From (FAO, 1980)

Table 1 - Land use in Lebanon

### Current stand

The status-quo of any component of Lebanon's land cover and/or land use is very much the consequence of the long interval of unstable conditions that prevailed in the country from 1975 to 1990 (local conflicts, military clashes, non-institutional control, hegemony of bad practices ... etc.). This particularly affected the agro-sector leading to its regression as witnessed by an almost 50% decrease in the number of workers between the 70's and 80's, and a 45% increase in families depending on income from migrating family members (Ba'albaki & Mahfouz, 1985). These conditions were widespread in the country, and intensified in rural areas where whole communities were forced to leave. Obviously, lands were deserted, forests were partially destroyed, agriculture and green cover deteriorated badly.

It was worst in southern Lebanon where Israeli military actions over two decades led to devastating socio-economic losses with considerable damages to the most productive agricultural land in citrus, bananas and tobacco. In addition, there was a consistent bombing and burning of forests and bushes leading to an increasing rate of land degradation, plus a persistent and uncontrolled withdrawal of huge amounts of water, both surficial and from the subsurface.

From another perspective, one should consider how much relevant laws are available for land planning, zoning and protection. More important is the presence of an environmental code and, of course, the extent of implementation. The law for construction considers that all unclassified land is open for exploitation, at a rate of 40% horizontal and 80% vertical coverage of the designated land cadastre. Sometimes these rates are even raised higher under certain conditions. Because the classified lands do not exceed 10% of the country, this makes a large proportion of land, even the agriculturally productive or rich with water resources, prone to be exploited in construction. This somehow unrestrained status, especially during the years of crisis 1975-1990, meant more widespread unchecked land exploitation and resource depletion.

Thus, the urban encroachment on rangelands, on forests, or other green cover and at the expense of further water depletion, was inevitable. Studies focusing on such impacts and losses are not many (Khawlie, 1986; 1995). The former paper relates to land use planning taking into consideration the geo-environmental characteristics of the land around Greater Beirut, while the latter deals with natural resource depletion focusing on three examples: soil erosion, green cover removal and changes in beaches. More recently, the use of advanced techniques of remote sensing started to give important contributions to this topic. Abed (1999) dwells on the assessment of post-war agricultural urbanization interface in Greater Beirut using change detection of HRV Spot images and GIS; Darwish et al., (1999) presents a well-documented case study on Tripoli's growth (second largest city in Lebanon) at the expense of productive agricultural land. Similarly, Awad & Khawlie (2000) emphasized the use of GIS as an integrated approach for natural resource protection especially applicable in regional urban development. An on-going research project concerning assessing the environmental impacts of urbanization in Mediterranean countries, including Beirut, has shown continuous urbanization of the coastal zone without any pre-determined plan, and short-term development goals dominating any long-term protection measures (Weber, et al., in press).

## METHODOLOGY

To monitor the recent changes in green cover and their impacts on the environment in general and on water resources in particular, information was gathered from available agricultural statistics as well as relevant maps at different time intervals to compare and contrast those changes. The 1963 agricultural map and the 1991 land cover map were digitized, their legends homogenized, and information plotted within the national administrative boundaries. Those boundaries plus layers of relevant data were treated in a GIS system for better manipulation and control on cross-checking for comparison purposes. This allowed a more realistic linkage to legislative and administrative aspects. In an area like Lebanon where climate fluctuations are transitional but within fairly known limits, climate alone is not enough to explain the deterioration. The socio-economic aspects are quite crucial. This is why assessment was made of relevant laws and regulations. Any relation between standard of living and mode of land exploitation is significant. In addition, other pertinent information were extracted from pilot studies in different areas in Lebanon reflecting on environmental impacts and the extent to which water resources are influenced. Recent agro-surveys done by the Ministry were also helpful in that respect.

## RESULTS AND DISCUSSION

### Agricultural change

Table 2 shows the status of land use comparing data of selective similar categories from the agricultural map of 1963 and that of the green cover map of 1990. There is generally an obvious decrease in agricultural lands, but with variable proportions. Olives, well known to be highly resistant and acclimatized, decreased only 31% compared to 72% and 82% of fruit trees and vineyards, respectively, mainly because of market losses. Citrus, on the other hand, decreased around 35% due to security reasons (the south), and chaotic urban encroachment especially in the coastal plains around major cities.

Land cover	Area km <sup>2</sup>		Change km <sup>2</sup>	Change %
	1963	1987		
Forest	934.3	629.8	-304.5	-32.5
Citrus	268	174	-94	-35
Fruits	544.6	195.6	-349	-72
Olives	437	301	-136	-31
Vineyards	365.8	65.2	-300.6	-82
Barren or deserted	1076.6	4370	+3294	+306

Table 2 - Change in some land cover over Lebanon between 1963 and 1987

## Forestry change

It is unfortunate that the lost agricultural lands indicated above were not replaced by forests, rather, the latter also decreased from the 1960's losing around 305 km<sup>2</sup>, i.e. approximately 32%. This meant an increase of deserted and barren land during that same period at almost three folds: from around 1076 km<sup>2</sup> to 4370 km<sup>2</sup>.

It is interesting to note that analysis of the distribution of the above figures on the 5 administrative provinces, Table 3 (Beirut is an independent province, but in the Table it is merged with Mount Lebanon as it lies at the center) reveals distinctive patterns. The largest decrease of 58% is in the inland semi-arid and dominantly agricultural Beka'a plain revealing that it is both the climate and human ill-practices causing that. The North and the Southern provinces' negative change is mostly due to neglect, land desertion, security and chaotic urban growth. Climate is not contributing significantly to deterioration in these two provinces, as well as that of Mount Lebanon. On the contrary, more adequate climate conditions probably helped preserve some, and even enhanced other forestry areas particularly in Mount Lebanon where the change is positive at 25%.

Mohafaza	Dominant Climate	Area km <sup>2</sup>		Change km <sup>2</sup>	Change %
		1963	1987		
Mount Lebanon	Mediterranean, cold, wet	212.6	265.8	+53.2	+25
Beka'a	Sub-continental, dry, semi arid	396.7	164.9	-231.8	-58
North	Mediterranean, mild, humid	255	228.3	-26.7	-10
South	Mediterranean, hot, humid	68.2	65.5	-2.7	-4

**Table 3 - Change in forest cover over the Administrative Provinces (Mohafaza) between 1963 and 1987**

It is important to stress in this regard, however, what seems to be as an element of "control" playing an effective role in preservation. The fact that Mount Lebanon province is at the geo-political "center", meaning that the Central Government at Beirut is there, implies that relevant authorities and mechanisms of control, implementation of codes and monitoring human practices, that normally occur in the "center", are actually contributing to that positive status.

## Water change

Although the previous changes are quantified to a considerable extent, the parallel changes in water resources accompanying them are not. There is a definite decrease in the overall water supply (Khawlie et al., 1997), especially due to climate change (Khawlie, 1999). But, the previous changes in green cover have also had their impacts on availability and quality of water. In the Beka'a where irrigation consumes up to 80%, the water table that used to be at about 10m to 15m is now down to around 50m or deeper. In the coastal plain areas where population is densest and urban encroachment is chaotic, more pollution is rendering large amounts of water unsuitable, plus the fact that salt-water intrusion is increasing. In the mountains and sloping lands where green cover removal increased, more and even severe soil erosion is taking place rendering surfaces more barren and easing up water run-off rather than infiltration.

From a total estimated range of 8.6 to 9.7 b.m<sup>3</sup> annual precipitation, Lebanon is using almost one third, while about 4.3 b.m<sup>3</sup> is lost through evapotranspiration, and 2.3 b.m<sup>3</sup> is lost to sea or out of the country. The terrain can be roughly divided into 5 hydrological basins whose average % recharge is about 25%, and whose annual balances are around (b.m<sup>3</sup>): 2.3, 2.7, 0.4, 2.2 and 1.6, respectively. But accurate data on water balances at basin level do not exist. Climatic fluctuations have more impact on the inner semi-arid to arid zone compared to the western Mediterranean zone. Again here the lack of updated laws and regulations on one hand, and poor implementation on the otherhand, are enhancing water losses and wastage. If, as postulated by the market demand-supply analysis, an annual gap (deficit) of up to 800 million cubic meters of water would be facing Lebanon within the end of this decade because of a marked increase on demand, it means that further deterioration in land-water interaction is inevitable.

## The role of laws and their implementation

From the previous sections, one can easily spot the link between applying (or not applying) relevant codes or regulations and the losses or degradation in green cover and water. In spite of the old laws protecting forestry, they are still quite effective,

if properly implemented. Examples include protecting them from grazing, cutting and burning, as well as reforestation within a defined time limit. But concurrently, those laws and a new one that came forth in 1996, do not allow even a proper use of the wealth of the canopy of the forest. This, in several instances, means lack of ecological management and, so often, led to overgrowth and natural fires.

Similarly, especially in coastal cities, the unregulated drilling of wells and pumping of subsurface water led to a critical decrease in the fresh water layer floating over the salty water resulting in increasing the salty water incursion in those cities. Before each building is constructed in Beirut, it starts with drilling a water well on site, so expectedly, the number of water wells rocketed from a couple of thousand in the sixties to more than fifty thousand now!

## Change in agricultural land use

Table 4 shows a comparison in areal extent of major agro-products which, distributed geographically and climatically as they are, play as a significant indicator of the extent and level of change. As was shown in Table 2, four out of the eleven major products were studied for change detection between the 1960's and 1980's. If their distribution is analyzed over the administrative provinces, again one finds a variable picture. Apples went back in the Beka'a much more than elsewhere; olives declined in all except the North; vinyards witnessed a total geographic decrease and so did the citrus plus other coastal fruits (bananas and loquat). It was noticed that in many instances either a chaotic multi-produce is planted at the expense of improper care, or plantations were deserted or barely attended to.

Administrative Province	Area of Orchards km <sup>2</sup>							
	1963				1987			
	Citrus	Fruit trees	Olives	Vineyards	Citrus	Fruit trees	Olives	Vineyards
Mount Lebanon	47.8	177.1	130.5	60.1	14.7	120.0	129.8	16.3
Beka'a	-	186.8	5.1	253.6	-	78.4	0.2	104.7
North	69.8	112.2	193.0	20.9	56.1	99.1	206.7	4.1
South	136.9	68.3	107.8	31.2	109.8	13.3	74.2	5.1
<b>Total</b>	<b>254.5</b>	<b>544.4</b>	<b>436.4</b>	<b>365.8</b>	<b>180.6</b>	<b>310.8</b>	<b>410.9</b>	<b>130.2</b>

Table 4 - Regression of major agro-products between 1960's and 1990's

## Socio-economic status change

In trying to explain this picture in Table 4, one finds that the causes of regression are not strictly climatic or environmental. There are economic reasons, i.e. cost of land, cost of labor in the agricultural sector, prices of produce in the unprotected market, as well as socio-political issues. This may probably have led to the increase in the production of vegetables using green houses, especially in the coastal plains. The statistics from Ministry of Agriculture show an increase from around 32000 to 82000 hectares between the 1960's and 1990's. Which is in contrast to the drastic decrease in cereals and legumes, from around 90000 to around 10000 hectares for the same period. Of course, the socio-political "driving force" is a crucial issue in explaining most noted changes.

More than half of Lebanon's population live in Beirut and its immediate surrounding areas. The North hosts 21.7%, the South 15.7% and only about 13% are in Beka'a (Ministry of Social Affairs, 1998). Similarly, people working in the agro sector make 20.4% of those living in Beka'a, around 15% in each of the North and South, and about 5% in Mount Lebanon (essentially nil in Beirut). Qualifying that with the levels of poverty (Haddad, 1994), reveals that those in the agricultural sector show the highest poverty, Table 5. Obviously, this explains why many are deserting the agricultural sector into something else, thus enhancing land degradation. The socio-economic status also explains the higher percentages of education in Mount Lebanon province compared to the others.

Level of Poverty	Agriculture	Industry	Commerce	Public Administration	Other Services	Total
Below relative poverty	71.7	9.5	1.8	12.4	4.6	100
Below absolute poverty	34.5	21.1	6.5	19.7	18.7	100

Source: (Haddad, 1994)

Table 5 - Percent (%) distribution of poverty in the major economic sectors of Lebanon

These have their implications not only on the profession chosen, but also on the willingness of the people to abide by the laws and regulations usually coming from the more affluent “Center”. Thus, communities in the “marginal” areas have a higher tendency to cut and burn forests. In fact, while the fairly educated could leave agriculture to some better productive sector, the uneducated, in trying to look for a better income would leave agriculture to graze in and cut forests. A typical case study showing these results was carried out around A’arsal in the semi-arid north eastern Beka’a (Ba’albaki, 2000). Large stretches of forests deteriorated due to grazing, many quarries opened up for aggregates, and plantations of fruit trees (cherries and apricots) spread, and they were also affected by the agricultural reform that took place in neighboring Syria across the borders (lands that the local community used to graze became restricted).

## Prospects and recommendations

Major Nation-wide adaptive and mitigation measures to overcome any negative effects on water resources are still at the planning level. Their application needs to give priority to the agricultural sector, i.e. decision to implement, as well as capacity building and financing. They have to focus on re-allocation of water consumption and distribution, legislative and institutional upgrading, monitoring and quality control, availing better/total information and coordination, as well as consider impacts of climate change. Local and minor-scale measures that could be mentioned are protecting forests and afforestation, establishing protected areas, terracing on sloping land to control run-off and erosion, limiting number, amount and depth of extraction of water wells, plus more effective pollution control.

Legislative aspects contributing to mitigation measures include “land use planning law” (1983), “law of construction” (1983), “law for forestry” (1949) and “law for forest protection” (1996). These must be upgraded to incorporate modern concepts of sustainable management and “eco-exploitation”.

From the previous sections, some simple and pragmatic recommendations are necessary:

- a- More accurate watershed assessment and resource utilization;
- b- A GIS interactive database on land use, change plus impacts on rangelands and forests;
- c- A quantitative analysis and modeling of specific impacts of the agro-entities on water resources;
- d- A projected analysis of the above in view of climate change in different bioclimatic zones;
- e- A workable, well coordinated, rangeland-water management and decision-making plan;
- f- A more integrated link between green cover, with agriculture, and the physical fabric of the land, i.e. including its resources of water, soil and forestry. ◆

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