LAND COVER CHANGE OVER THE LAST 40 YEARS IN LEBANON

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ABSTRACT

Land 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 a major reference for evaluating any change. 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 crisis events of 1975 to 1990 and the Israeli military aggressions resulted in huge agro and natural cover damage and land degradation. Mismanagement of water supply was an additional aggravating factor.

Change detection studies relied on analyzing data from the 1963 agricultural map and the land cover map of 1990's plus updates using Landsat TM and SPOT XS imageries acquired in 1998. Due to the mutli-thematic nature of the landcover, and the complexity of factors influencing change, data were introduced in a GIS system for manipulation. The study shows that there is an overall reduction in agricultural areas varying from 31% in olives, 32.5% in forestry, 35% in citrus, 72% in fruit trees, and 82% in vineyards. Generally, urbanization increased locally anywhere from 25% to more than 100%. The proportions vary among the different provinces influenced by several socio-economic factors. In Beka'a, where most agriculture occurs, the largest land degradation and forest cover removal have taken place. Lebanon has thus far lost about 32% of its forest cover.

Keywords: green cover, land degradation, Lebanon

INTRODUCTION

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. The impacts were land degradation in the former and excessive demand on water in the latter. Most notably, this was experienced in Beirut, the capital, growing from a population of about 450000 in the 1960's to become currently close to two millions.

These changes, and the associated changes in life styles, resulted in a deep impact on land use and resources. Statistical information from the Ministry of Agriculture show now that agricultural surfaces occupy 2611 km^2, among them cereal 20%, fruit trees 23%, olive 20%, legumes 17%, others 20% (MoA, 2000).

The statistical data of 1960's and 1990's were compiled through field surveys and areas estimated by interviewing the farmers, because the cadastral maps in Lebanon cover only 50% of the territory. In addition, the data are not geo-referenced, and therefore one cannot detect the spatial change reliably between the 1960's and the 1990's. Boulos (1963; 1980) produced the agricultural map using the available aerial photos at a scale of 1/25000 covering all Lebanon. This map was printed in a hardcopy format, and the latest edition was in 1980. In 1990, FAO, in cooperation with the Ministry of Agriculture, produced the land cover maps of Lebanon at a scale of 1/50000 using satellite images from 1987.

Forests occupy 1357.5 km^2, and rangeland occupies 3471 km^2, the rest being primarily agriculture, 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 policies did not gear into organized and properly functioning development sectors: imported produce and an ill-structured market. The high cost of working the land in mountainous areas made its rural community most vulnerable. Expectedly, this led to abandoning the mountain farms, notably grapes, olives and apples that constituted then the backbone of the agro-economy.

The current *status-quo* of any component of Lebanon's land cover and/or land use is very much the consequence of the long interval of crisis that prevailed in the country from 1975 to 1990 (local conflicts, military clashes, non-institutional control, hegemony of bad practices, intense exploitation of resources … *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 1970's and 1980's, and a 45% increase in families depending on income from migrating family members (Baalbaki & Mahfouz, 1985). Lands were deserted, forests were partially destroyed, with agriculture and green cover deteriorating badly.

The situation was worse in southern Lebanon as a result of the Israeli occupation and the resultant shelling and burning of forests, bushes and agricultural land. This resulted in internal migration, land desertion and a collapse of water distribution and management systems.

As far as relevant land planning, protection and zoning legislation is concerned, there is a general consensus that these need to be reviewed in order to reflect needs and future trends more effectively. In Lebanon, all unclassified land is open to urban exploitation at 40% horizontal and 80% vertical coverage. Since classified land does not exceed 10% of the country, this results in the urban exploitation of green cover.

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; 1991). 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 Lebanon, 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 preparation).

This paper aims at detecting the change in green cover that took place in Lebanon over the last forty years. The subject matter is not simple in the sense that one is recording only the physical change. It surpasses that to relate to the ways in which that green cover was studied over that time interval, as well as the driving forces that caused the change. This is significant because those forces, or causes of change, link not only to the community itself, *e.g.* population stress on land here, or increasing demand for water there … but also to the policies and regulations controlling land use and sectoral growth. In addition, a possible impact of green cover degradation due to climate change should not be ruled out.

METHODOLOGY

To monitor the recent changes in green cover and their impacts on the environment, information was gathered from available agricultural statistics as well as relevant maps, and two satellite images: Landsat TM and SPOT XS (1998), in order to compare and contrast those changes. Baseline agro-statistics go back to 1963, advantaged then with a land survey coverage by aerial photography and physical mapping. The agricultural map was produced through the use of aerial photos at a scale of 1:25000, and included the following class legend: 1. unplanted rocky land partially used as mountain lakes, 2. forsaken and unplanted lands, 3. apples, 4. citrus, 5. different fruit trees, 6. olives, 7. vineyards, 8. tobacco, 9. cereals, 10. vegetables, 11. forest, 12. various irrigated lands. These classes are sometimes defined on the 1:20000 topo map while in other cases they are not, *e.g*. the irrigated lands. Those that are defined were digitized and merged, thus the resultant agro map included only 6 classes: 1. forest, 2. fruit trees (covering apples and others), 3. citrus (also covers bananas and loquat), 4. olives, 5. vineyards, 6. forsaken lands.

The same resultant six classes above show up in the FAO (1990) land cover map at 1:50000, which was produced through using SPOT, Landsat and KVR 1000 satellite imageries. But those classes are observed, in several instances, to mingle with each other, like olives with forest or with urban or irrigated areas. Obviously, those had to be separated, or at least resolve the pure from the mingled classes. Thus it was possible to distinguish the changes that took place over those classes since the sixties, as compared to imageries taken recently.

Several important "covers" (land cover, land use … *etc*.) were produced recently by using satellite imagery for mapping purposes. These include the land use map of Greater Beirut (IAURIF, 1987), the land use maps of the coastal stretch (10 km wide ribbon) (ECODIT, 1996) and that of southern Lebanon (IAURIF, 1999). As can be noted from those maps, they do not have the same class legend as that of the 1960 agro map. The land cover map of FAO (1990), however, that used satellite imageries from 1987, has a more closer approach to the requirements of the present study concerning change detection.

The land cover map of 1990 was very useful in producing the land cover map of 1998 using Landsat TM and SPOT XS acquired in September 1998. These images were geometrically corrected using ground control points from topographic maps (scale 1/50000) and GPS. The interpretation was done at a scale of 1/200000 using the FAO's map legend, and it was stratified similarly to the land cover map of 1963, *i.e*. into five classes: Forest, Citrus, Olives, Vineyards and Bare lands.

The digitized agricultural map of 1963 and the 1998 updated land cover map were homogenized, and information overlayed within the national administrative boundaries. Those boundaries plus layers of relevant data extracted from the proceeding were treated in a GIS system for manipulation and cross-checking for comparative 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 observed 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 was 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

To understand better the change detection approach used, it is important to give a background that explains the baseline data. The agricultural map of 1963 was used as baseline reference with regard to the types of agricultural green cover and land exploitation. That gives an idea, to a certain extent, of how good or how bad was the land use or practices. 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. This led to accentuate land degradation because 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 other industrial pollutants. Table 1 is a background 1980 data that helps reflect on land use, where one can immediately notice the large portion of rocky uncultivated land at 52%, followed by arable land at 25%.

TABLE 1
Land Use in Lebanon, 1980

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

Adapted from (FAO/UNDP, 1980)

Agricultural change

Table 2 shows the status of land use comparing data of selective similar categories from 1963 and 1998. 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 in the south, and chaotic urban encroachment especially in the coastal plains around major cities.

TABLE 2
Change in Some Land Cover over Lebanon between 1963 & 1998

Land cover	Area km^2		Change km^2	Change %
	1963	1998		
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
Vinyards	365.8	65.2	-300.6	-82
Barren or deserted	1076.6	4370	+3294	+306

Forestry change

It is unfortunate that the lost agricultural lands indicated above were not replaced by forests, rather, the latter also decreased from 1963 losing around 305 km^2, *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^2 to 4370 km^2.

Analysis of the above-mentioned results from the the 5 Mohafazas shows distinctive patterns (Table 3) (Beirut is an independent Mohafaza, but in the Table it is merged with Mount Lebanon as it lies at the center). The largest forest decrease of 58% is in the inland semi-arid and dominantly agricultural Beka'a plain. In this inner and remote area, the increasing rate of deterioration of the land cover can be attributed to both natural and

anthropic causes. The former is explained by a trend of decreasing precipitation, *i.e*. less or equal to 300 mm annually. The latter is due to socio-economic pressures overtaking the local community since the late fifties especially affecting their limited access to ranges in nearby Syria (Baalbaki, 2000), as well as unproductive land in poor forest areas (Figure 2). The negative change in the North and the Southern provinces is mostly due to neglect, land desertion, security and chaotic urban sprawl. Climate is not a major contributing factor to land deterioration in these two provinces, as well as that of Mount Lebanon. On the contrary, more adequate climatic conditions probably helped preserve some, and even enhanced other forestry areas particularly in Mount Lebanon where the change is positive at 25% (Figure 1).

TABLE 3
Change in Forest Cover over the Administrative Provinces (Mohafaza) between 1963 & 1998

Mohafaza	Dominant Climate	Area km^2		Change km^2	Change %
		1963	1998		
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

It is important to stress in this regard what seems to be an element of "control" playing an effective role in preservation - Mount Lebanon being in the vicinity of the administrative centre of the country, Beirut, has been relatively spared the ravages seen in the more distant Mohafazas.

The role of legislation 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 land. Inspite of the fact that the laws protecting forests are old, they would still be quite effective if properly implemented. Examples include protection from grazing (Masri, 1997), cutting and burning, as well as reforestation within a defined time limit. But concurrently those laws, and a recent 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 is leading often to overgrowth and natural fires.

Change in agricultural land use

Figure 3 shows the regression in areal extent of major agro-products over the Mohafazas which, distributed geographically and climatically as they are, reflect 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 1963 and 1998. If their distribution is analyzed over the administrative Mohafazas again one finds a variable picture. Apple production drew back in the Beka'a much more than elsewhere; olives declined in all except

the North; vineyards witnessed a total geographic decrease and so did the citrus plus other coastal fruits (bananas and loquat). It is noticed that in many instances either a chaotic multi-produce is planted, or plantations were deserted or barely attended to.

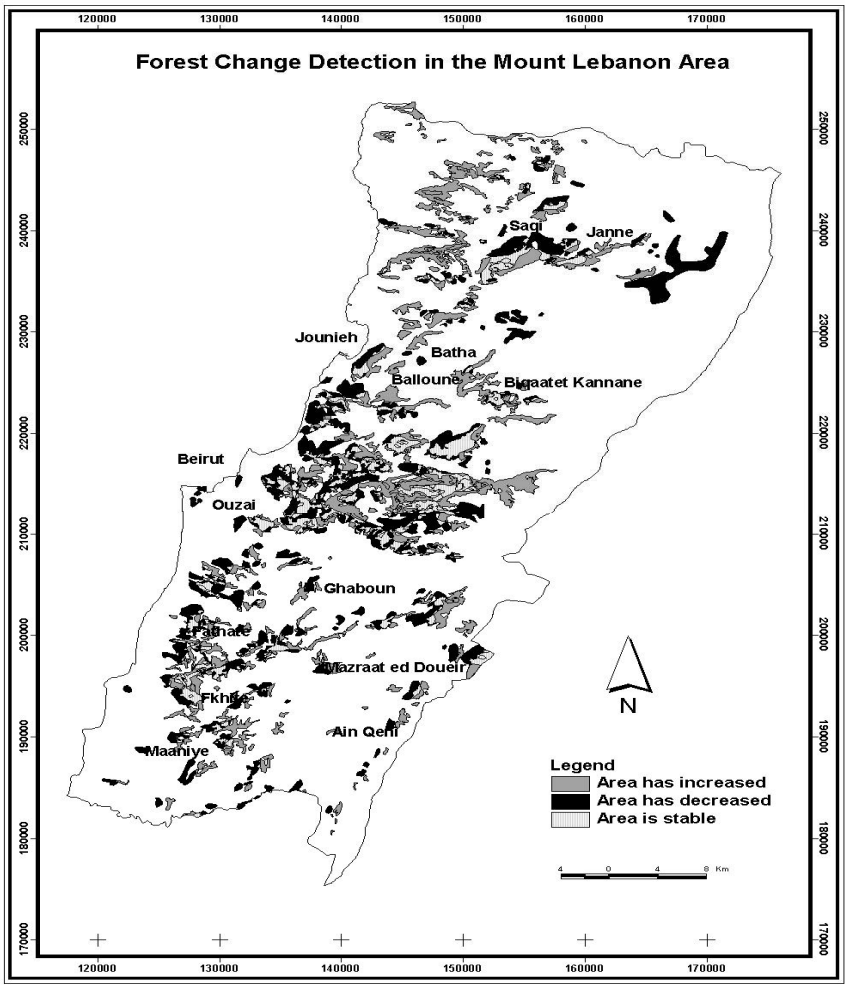

Figure 1.

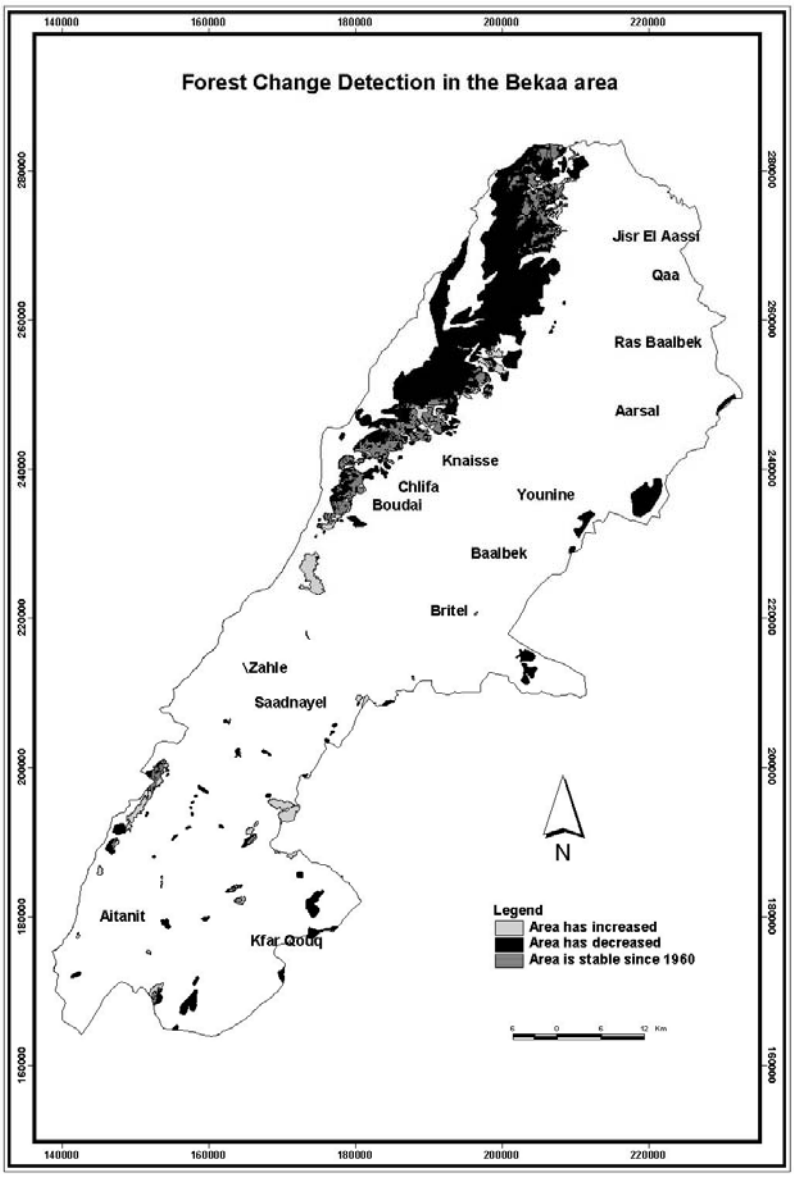
Forest Change Detection in the Bekaa area
140000
160000
180000
200000
220000
280000
260000
240000
220000
200000
180000
160000
Jisr El Aassi
Qaa
Ras Baalbek
Aarsal
Knaisse
Chlifa
Boudai
Younine
Baalbek
Britel
\Zahle
Saadnayel
Aitanit
Kfar Qouq
N
Legend
Area has increased
Area has decreased
Area is stable since 1960
6 0 6 12 Km

Figure 2.

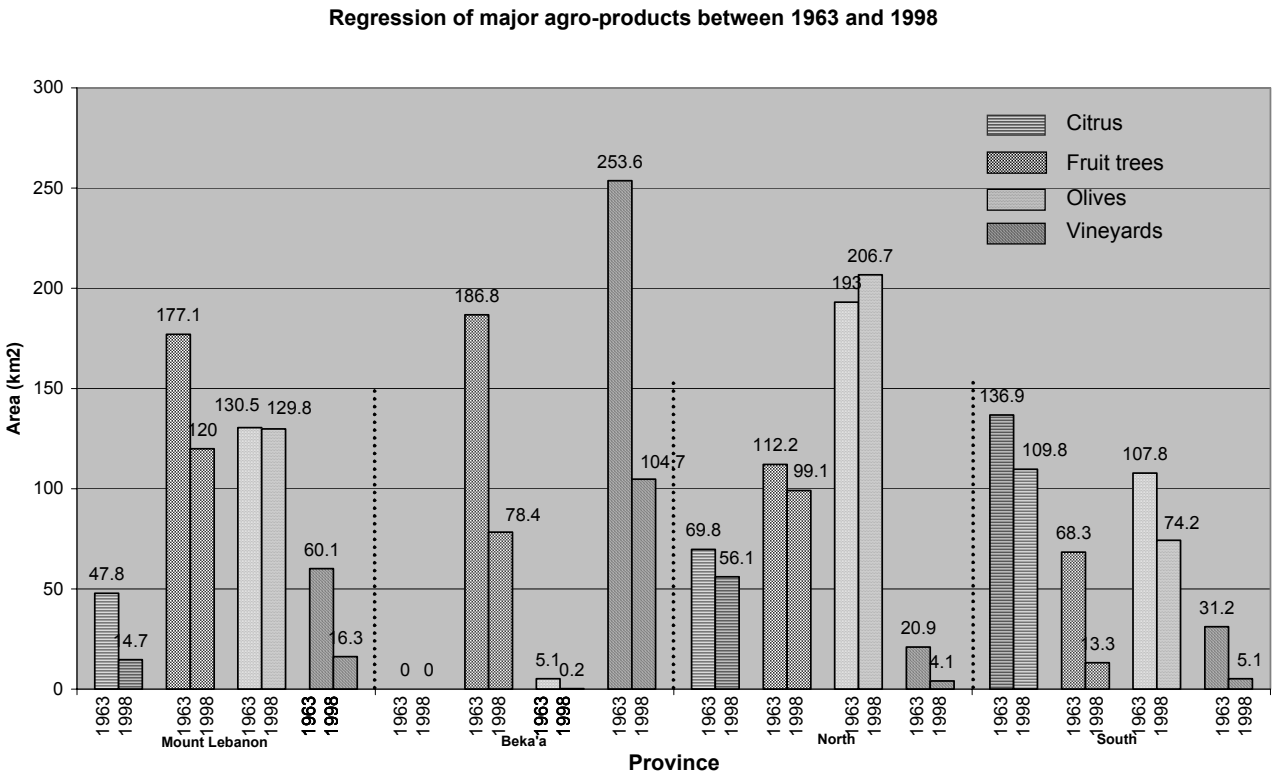
Regression of major agro-products between 1963 and 1998
Citrus
Fruit trees
Olives
Vineyards
Area (km2)
300
250
200
150
100
50
0
47.8
4.7
177.1
120
130.5
129.8
60.1
16.3
0 0
186.8
78.4
5.1
0.2
253.6
104.7
69.8
56.1
112.2
99.1
193
206.7
20.9
4.1
136.9
109.8
68.3
13.3
107.8
74.2
31.2
5.1
1963 1998
Mount Lebanon
Beka'a
North
South
Province

Figure 3.

Socio-economic status/change

In trying to explain the picture in Figure 3, 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 probably may 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 1963 and late 1990's. Which is in contrast to the drastic decrease in cereals and legumes, from around 90000 to around 10000 hectares over 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 lives 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/FAO, 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 4). This is one reason why many are deserting the agricultural sector for more profitable employment, thus contributing indirectly to land degradation. The socio-economic status also explains the higher percentages of education in Mount Lebanon mohafaza compared to the others.

TABLE 4
Percent (%) Distribution of Poverty in the Major Economic Sectors of Lebanon

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

Source: (Haddad, 1994)

These aspects 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 would leave agriculture to some better productive sector, the uneducated, in trying to look for a better income would leave agriculture to grazing and cutting forests. A typical case study showing these results was carried out around A'arsal in the semi-arid north eastern Beka'a (Baalbaki, 2000). Large stretches of forests deteriorated due to grazing, as well as quarries for aggregates, plantations of fruit trees (cherries and apricots) spread, and the community was 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).

CONCLUSION AND RECOMMENDATIONS

The study is essentially a comparative analysis of the vegetative land cover during the second half of the twentieth century. Previous data from old maps, agro statistics and information of 1963 were compared to more recent ones produced in the National Council for Scientific Research from the updated land cover map of 1998 obtained from satellite imageries. The outcome reveals a clear decline in forestry and fruits, with different geographic proportions, *e.g.* forest decline in Beka'a is 58% compared to 10% and 4% in the North and South, respectively. The study explains that outcome due to several factors: environmental, legislative, and socio-political/socio-economic which pertains to the differential standards of living across the country.

The comparison shed light on the nature of change and its trend, but not necessarily an accurate quantification. This, of course, is expected when using different scale maps and having different base characteristics, *i.e*. how were they produced, from aerial photos, or field surveys, or satellite imageries … *etc*. it makes the final product different. It is significant to mention in this regard that work is being undertaken to produce a 1:20000 scale land use/cover map from high resolution satellite imagery, about 5 m, which will definitely allow a more detailed and accurate detection of the green cover in Lebanon.

From the previous sections, some simple and pragmatic ideas emanate to be considered by decision-makers. Theses ideas can be considered as recommendations and categorised in three main areas: the need to avail upgraded and updated databases on natural resources and their exploitation. The need to introduce new and more relevant codes and regulations for environmental control and information management. And an obvious need for advanced techniques in modeling and certainly in integrating natural resources within a sustainable development programme for the country.

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