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A PERSPECTIVE ON SOIL EROSION AND CONSERVATION

IN

LEBANON

JOHN RYAN

Publication No. 69
November, 1982

Associate Professor of Soils and Certified Professional Soil Scientist, Department of Soils, Irrigation and Mechanization, Faculty of Agricultural and Food Sciences, American University of Beirut.

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"These resolutions..... firmly established the legitimacy of our rights, supported the sanctify of our soil".

H.E. Amin Gemayel, President of Lebanon
before the Security Council, October, 1982

"All that we have been and all that we are and all that we are ever likely to be – from the humblest toiler to the greatest spiritual leader – we owe to the soil".

Kermit C. Berger
in Sun, Soil and Survival (1972)

OUTLINE

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J.R.

ABSTRACT

Soil erosion is, today, the major environmental problem facing mankind and one which has profound implications for man's food supply. While generally acknowledged to be of increasing significance in the Middle East, the magnitude of this insidious "silent earthquake" is largely unrecognized by society and its leaders. This publication is an attempt to redress this unfortunate situation. It involves: an overview of the soil erosion-conservation problem, including the reasons and means for conservation, together with a list of common obstacles to such endeavors; an historical review of the subject in the Middle East region and Lebanon in particular; a review of the erosion-related studies that have been conducted at the American University of Beirut – mainly at its field station in the Beka'a valley i.e. the Agricultural Research and Education Center; miscellaneous land use-related studies in Lebanon; a review of Lebanon's Green Plan, within whose mandate the task of soil conservation and land development falls; a brief description of international programs and policies in land use and management, and, finally, the presentation of some pertinent conclusions and some thoughts or recommendations for future action in this vital area of national concern. The urgency for action by both public and private sectors in stressed in order that this generation may pass on the land of Lebanon to the next generation, in a better-not a worse-condition. *Making people aware is the first step in this direction.*

INTRODUCTION

The land resources of this earth are closely related to agricultural, and hence food, production. A deterioration in these vital resources constitutes an ominous threat to man's survival. Land deterioration or degradation can be defined as loss of productivity, quantitively or qualitatively, through various processes such as erosion by wind and water, salinization, waterlogging, nutrient depletion, soil structural deterioration, and pollution (Dudal, 1981).

While only rough estimates are available regarding the extent of soil loss globally, they are, nevertheless, astounding and profoundly disturbing in their implications. Total historic soil loss has been put at 2 billion hectares; the present arable area of the world being about 1.5 billion hectares. Currently, yearly estimates of soil loss have been put at 5-7 million hectares (Kovda, 1977). The consequences of such mindless destruction are obvious. The problem supersedes political boundaries; though much is written about erosion in the U.S., it also manifests itself with detrimental consequences in the U.S.S.R. (Tregulov, 1981) and in China (Deqi *et al.*, 1981) as well. The implications of massive and indiscriminate deforestation of the Himalayas in promoting erosion on an unprecendented scale, and its effect on dislocating and impoverishing rural communities, have recently jarred the public consciousness in India through the popular press (see Illustrated Weekly of India, March 14, 1982).

This issue, in all its complexity, has to be given the utmost priority by our planners and policy-makers at national, regional and global levels. *Conservation, in its broadest sense of responsible and intelligent use of land and water resources, is the strategy to combat such destruction.* The movement has to fight for preservation of agricultural land for agricultural use. In many countries, development involves the permanent burying of land under concrete and asphalt – often the best land. This phenomenon is particularly alarming for Lebanon whose supply of prime agricultural land is small by comparison with its total land area and its population. *Whether lost or degraded through erosion or covered with concrete, the consequences for food production are the same – the soil as a source of production no longer exists.* Soil does not reproduce itself within our time framework, unlike man, who is at the opposite side of the food supply – demand equation.

As we look into history we find that balancing this equation has been a major, if not the only, preoccupation of man. Though the terraces of the old world i.e. Phoenicia, Yemen, and Peru, stand as mute evidence of historical concerns about erosion, conservation as an organized movement essentially emerged in the U.S. in the mid thirties in response to the "Dust Bowl" (Stallings, 1957). From its modest beginnings, conservation rapidly gained momentum, taking its place in soil science as a separate discipline and gaining a foothold in agricultural college curricula in the U.S. and elsewhere. Conservation as a concept has intruded upon, and become firmly embedded in socity's collective conscience. Conservation is now a major consideration for farmers, agriculturalists, planners and indeed politicians. *Regrettably, however, the seed of conservation has not germinated and flourished in many countries of the world; countries which, ironically, have the greatest threat to land degradation and, at the same time, burgeoning populations generating increased food demand.*

As the last two decades saw the ushering in of the era of the "global village", the plight of the less fortunate in the Third World cannot escape the attention of those who are better-off elsewhere. The obligation to redress the inequalities in the human condition globally is both moral and expedient.

The concern for soil conservation was given considerable impetus when it found common ground, as it were, and coalesced with the broader "environmental" movement. This concern was evidenced by the number of international conferences i.e. UN Conference on the Environment in Stockholm, 1972; the national conference on Soil Erosion: Prediction and Control at Purdue University, 1976; UN Conference on Desertification in Nairobi, 1977; and the International Conference on Soil Conservation in Silsoe, Bedford, U.K., 1980.

The plethora of publications emanating from the Food and Agriculture Organization of the UN further underscores this international concern. These dealt with soil erosion assessment (1974, 1977, 1979), land degradation (1971), land evaluation (1976a); guidelines for watershed management (1977b), hydrological techniques for upstream conservation (1976b), and conservation in arid and semi-arid zones (1976c) and in developing countries (1977c). Though not complete, this list serves as an example of the fund of technical information available to support conservation programs especially in developing countries.

Various texts, too, have made a significant impact in inculcating the principles of soil conservation in the minds of those who are to work in the field. That of Stallings (1957) has a special and time-honored place among the many available. Others worthy of note include Hudson (1971) with its engineering slant and, more recently, Troeh *et al.* (1980) which focuses on a broad spectrum of conservation issues, making special reference to the arid and semi-arid regions.

Notwithstanding these sources, soil degradation on a global scale continues largely unabated. The situation in the Middle East region -- a food deficit area – is particularly acute. This publication coincides with a recent UN report – March '82 – which cited soil erosion as the major cause of a fall in living standards in many parts of the world, including Africa and the Middle East. Even in the U.S., the revelation that currently about 5 tons of topsoil is washed away for each acre of cropped land each year has shocked farmers from a state of complacency.

This rather gloomy picture raises serious questions regarding the effectiveness of technology transfer in the area of soil and water conservation. Hudson (1981) concluded that although there are gaps in present-day technology, *the major constraint to the implementation of erosion control is due to factors of a social, economic and political nature.* This publication is an attempt to tackle the problem of degradation of soil and environment at the awareness level. *It represents a plea to politicians, planners, and farmers and all whose destinies are tied, in one way or another, to the land of the Middle East to act quickly before it is too late.* In order to achieve this lofty goal, the principles involved in erosion are defined, the historical significance of the subject is outlined, relevant erosion-conservation studies are interpreted in action terms, and some thoughts are presented in order to stimulate action by those who owe it to posterity, and who are in a position, to do so.

Though not hailed as a panacea or remedy for the obvious deficiencies in land use management in the region, the author hopes that this publication will catalyze a greater degree of public awareness of such environmental issues. Unless this awareness exists at local level, programs imposed by the Government are likely to fail. *We, the present generation, are only custodians – not owners of the land. We must account for our stewardship to future generations.* Will our legacy be a silent barren treeless landscape and polluted waters – fulfilling the dire predictions of "Silent Spring"? Or will the Lebanon of the future be a land of bounty and restored beauty? *We all can do our share, either collectively or as individuals, to influence this choice.*

OVERVIEW OF SOIL EROSION

As a prerequisite for the general reader, it is important in a review of specific soil erosion and conservation studies, to present sufficient background information so that the findings can be meaningfully interpreted and placed in a proper context. As with all studies of this kind, the justification for such an undertaking by individuals or society has to be made. In addition, in this instance, a synopsis is presented of soil and water conservation techniques as well as obstacles to the implementation of these techniques. Both aspects have to be considered in any goal an action-oriented program.

Rationale for Conservation

Soil is man's vital resource for the production of food, fiber and the necessities of life. Its rate of formation from rock or geological materials is so slow that it can be considered nonrenewable resource. Soil erosion results in removal or depletion of this thin mantle of material on the earth's crust. *While matter as such cannot be destroyed, the soil as a medium for plant growth can.* It is translocated from the farmer's field, where it is useful, to sites of deposition, where it is useless and frequently harmful. *It has implications therefore for the farmer and society as a whole.*

The process of erosion, either by wind or water, is selective; the finer and nutrient-rich clay particles and organic matter are removed first, leaving behind a soil which is not only poorer in fertility but also degraded physically and biologically. Erosion can, for a long time, go unnoticed when soil is removed uniformly and in thin layers. The ultimate effect is not always obvious until a substantial depth of soil has been removed and the fertility and productivity has declined. However, more frequently, erosion is intermittent; most of the soil loss may take place within a few days while one part of a field may be severely eroded and another part unaffected. *The acceptable limit of soil loss tolerance is based on the fact that the amount of soil eroded should not exceed the rate of soil formation.* A given amount of soil loss from a shallow soil has greater consequences for productivity than from a deep soil. Where erosion is severe, values greater than 10 tons/ha are not uncommon. Under such circumstances it is easy to visualize the entire soil being washed away.

Under natural vegetation, soil loss through erosion is more or less in equilibrium or balance with the rate of soil formation. Removal of vegetation by cultivating cropland, by grazing pasture or rangeland or by cutting trees nearly always increases the rare of soil erosion i.e. accelerated erosion. Invariably, such activities by man leave the soil more exposed to the detaching action of raindrop impact and the transporting action of runoff water and wind. Rills, gullies, and sand dunes are all manifestations of this phenomenon.

The *reasons why society should be concerned with this problem are many.* Loss of fertility means loss of productivity. In the past, this was largely compensated for by bringing new lands into production in response to the food demands of an ever-increasing population. However, the land base in recent decades has been relatively constant. Virtually all the world's favourable agricultural land has been put in use; new lands can be developed and large areas put into production by irrigation but the costs are high, sometimes exorbitant. This, in any event, would be offset by diversion of land for non-agricultural purposes. Increased production must now come from higher yields and more intense use of existing cropland. The shortfall in soil fertility, accentuated through nutrient loss by erosion, has to be made by commercial fertilizers, the added costs of which can be considerable for society. Furthermore, more intensive agriculture brings with it a greater potential for erosion if corresponding improvements in management do not occur.

A more recent spectrum of concerns has been in the area of the environment. Nutrients removed from agricultural land – principally nitrates and phosphates – are major causes of pollution for inland waters i.e. eutrophication of lakes, etc. Nitrates which seep into drinking water supplies may have adverse effects on human health. Pesticides attached to soil particles may have detrimental effects on fish and wildlife. Eroded

soil may fill up reservoirs, thus reducing capacity for water storage and the generation of electrical power. Siltation of harbours, damage to watercourses, and destruction of fisheries are just a few of the other effects of erosion by water. Air pollution by dust, with its adverse effects on human health, is another consequence of erosion. Soil conservation, which involves using the soil while maintaining its productive capacity, is the obvious antidote to these problems.

Conservation Techniques

In any land management program, it is imperative to appreciate those soil properties which are basic to soil and water conservation as described by Troeh *et al.* (1980).

"Soil topography includes the gradient, length, shape, and aspect (direction) of slopes. These features control the concentration or dispersion of erosive forces such as runoff water and wind. Topography also influences the practicality of erosion control practices such as contouring, strip cropping, and terracing. These practices may be very helpful on long, smooth slopes but impractical on rolling topography with short, steep slopes.

Soil depth, the nature and thickness of the soil horizons, and the underlying rock material greatly affect the rate of soil formation and the tolerable rate of erosion. The erosion tolerance is much lower for shallow soils over hard bedrock than it is for deep soils underlain by unconsolidated material such as loess. Subsoils with high clay contents or other unfavorable properties also need to be covered with topsoil to support plant growth. Deep soil is favorable for water storage and plant growth. Where the soil is shallow, it may be impossible to smooth the land for drainage and irrigation or to move soil for building terraces and ponds.

Soil permeability and the rate of rainfall or irrigation determine how much water will run off and cause erosion. Conditions that most commonly limit soil permeability are a soil surface puddled by rain-drops or traffic, plowsoles or other highly compacted layers, heavy subsoils with only small pores for water passages, frozen soil, and bedrock or cemented layers. The closer a restrictive layer is to the soil surface, the less water is required to saturate the soil above it and cause runoff to begin. Soil permeability also influences the functioning of subsurface drainage systems and of septic tank drain fields.

Soil texture and structure both influence soil permeability and erodibility. The clay in a soil helps it cohere either into a solid mass or into structural units with pore space between them. Individual clay particles are difficult to detach from a soil but can easily be moved long distances after they are detached. Sand particles are easily detached from sandy soils, but a high velocity of water is required to move them very far. Silty soils are often the most erodible by water, because the silt particles are too large to stick together well and are small enough, however, to resist detachment by wind unless they are knocked loose by something else, such as moving sand particles.

Soil fertility is important to soil conservation because plant growth helps protect the soil. The more vigorous growth produced on a fertile soil provides better protection and is less likely to leave bare spots vulnerable to erosion. Fertilizers are therefore important for soil conservation."

These properties can be presented in soil maps which serve as a basis for subsequent decisions dealing with either general principles of land use or specific vegetative or mechanical practices. Again, following Troeh *et al.* (1980):

"Land Use and Management

One of the first considerations of a soil conservationist is the use of land within its capabilities. Some land is suited for intensive cropping – especially where the soil is deep, level, fertile, and well drained and has favorable texture and structure. Other land is so steep, shallow, stony, or otherwise limited that it is suitable only for wildlife, recreation, or other uses that cause no erosion. Many gradations exist between these two extremes. *Most land is suitable for some uses but unsuitable for others.*

Land use can be broadly classified into cropland, pastureland, woodland, wildlife and recreational land, and miscellaneous use. Each broad class can be subdivided several times. For example, cropland in-

cludes land used for cultivated row crops, small grain crops, and hay crops. The soil exposure to erosive forces declines from row crops to small grain crops to hay crops because of differing growth habits and management techniques. *The exposure to erosive forces continues to decline from cropland to pasture and woodland and then to wildlife land.* These latter uses are therefore considered to be of progressively lower intensity.

Management can alter the effect of a single type of land use on a wide range of erosive tendencies. Row crops, for example, can be grown in wide or narrow rows that may or may not follow contour lines. There may not be a lengthy exposure to the elements between the harvesting of one crop and the protective growth of the next. The soil may or may not be protected by crop residues or by special cover crops during periods when the main crop is not on the land. Each of these variables has a considerable effect on the amount of erosion that is likely to occur.

Variations also occur with other types of land use. Pasture, for example, may have grasses and legumes that were specially selected to provide ground cover and forage, or it may have whatever happens to grow. The number of livestock per hectare may be limited to what the pasture can readily support, or it may be so large that overgrazing kills part of the vegetation. Both extremes may occur in the same pasture if the livestock are permitted to spend too much time in one area. Also, both soil and vegetation may be damaged by trampling if livestock are allowed to graze when the soil is too wet.

Vegetative and Mechanical Practices

Conservation techniques are often divided into vegetative and mechanical practices. There is no good reason for always favoring one type over the other; both include a wide variety of methods of protecting soil against erosive forces. The best approach in many situations requires a combination of vegetative and mechanical practices.

Vegetative practices include techniques that provide denser vegetative cover for a larger percentage of the time. *Changing to less intensive land use is usually a very effective means of reducing erosion.* The problem with less intensive land use is that it usually is less profitable. A compromise using a series of different crops with some providing more income and some giving more soil protection is known as a crop rotation. Crops grown for the sole purpose of protecting soil between other crops are known as cover crops.

Choices of land use, crop rotations, and cover crops are all vegetative means of erosion control. They need to be accompanied by good management techniques that help each crop grow well. Good seed planted at the right time in a proper seedbed helps get the crop off to a good start. Adequate fertilizer and lime where needed promote vigorous growth. Narrow row spacing allows a row crop to provide better soil cover sooner. These management techniques generally improve both yield and erosion control.

Placement of special vegetation in critical places also is important. Grassed waterways can prevent the formation of gullies. Windbreaks can direct the wind stream away from erodible land. Various forms of strip cropping reduce water erosion, wind erosion, and pollution. Appropriate plantings in odd corners, steep slopes, or other problem areas provide food and cover for wildlife as well as erosion control. Special plantings are needed also for disturbed areas such as roadbanks and mine spoils.

Vegetative methods can limit erosion to geologic rates. Grasses, trees, and other plants are nature's tools for controlling erosion; the rate of erosion that native vegetation allows defines the geologic rate for a particular setting. Though geologic rates are usually quite slow, they occasionally are as sudden and rapid as a landslide. Sometimes the rate of erosion should be reduced below the geologic rate by providing more than the natural amount of protection. More often, some increase above the geologic rate is allowable.

Mechanical methods broaden the choice of vegetation and allow a higher-income crop to be grown even though the crop provides less soil protection. Contour tillage, for example, can often reduce erosion to half that resulting from random orientation to the slope. Leaving most of the crop residues on the soil surface by reducing the amount of tillage reduces erosion markedly. Further reductions can be achieved by building a terrace system to prevent eroded soil from leaving the field. Soil movement may occur between terraces, but the soil is deposited in terrace channels rather than being allowed to pollute a stream. Of course, the

channels must be cleaned periodically as a part of terrace maintenance.

Various structures made of concrete, wood, metal, or some other sturdy material are used to control erosion by controlling water flow. Critical points occur where water must be dropped from a higher elevation to a lower one. The soil may be protected by conducting the water through a pipeline, down a flume or chute, or over a drop structure. Pilings, riprap, or other bank protection may be used to keep a stream from meandering to a new location.

Mechanical methods of erosion control tend to be either very inexpensive or very expensive. Conservation tillage practices save fuel, time, and money by reducing the total amount of work done on the soil. Also, conservation tillage often combines two or three operations into one and therefore requires fewer trips across the field. Reorienting the direction of tillage to a contour system may require more planning and layout and add the inconvenience of many short rows, but it normally costs no more than conventional tillage. The fuel requirement for working across the slope is usually slightly less than that for up and down the slope.

Tillage changes require no new investments unless new equipment is needed. On the other hand, these inexpensive or money-saving practices are short-lived and must be repeated with each new crop. Most longer-lived, mechanical methods of erosion control involve expensive structures such as terraces, dams, and drop structures. The earth moving and concrete works required are costly. Expensive structures are usually justified by their many years of usefulness and increase flexibility of land use".

As can be seen from the above discussion, decisions regarding land management for conservation are most often complex. Though the arguments for conservation measures are compelling, those for resisting implementation of such measures may by equally compelling in the mind of the farmer.

Obstacles to Conservation

Perhaps the major deterrent to conservation measures is the economic one. How much will it cost? What returns can be expected? Will the cost be repaid in a short time? in a long time? or not at all? Such practices vary greatly in terms of costs, returns, and effectiveness. The easiest practices to promote are those that will return a profit within a short time. For example, a good fertilizer program returns a profit as soon as the crop is harvested and helps conserve soil at the same time. Longer-term practices such as liming and soil drainage may be recognized as desirable for some time before the necessary financing can be arranged. The time lag is still longer for terracing and other practices that have high investment costs requiring many years to repay. Least popular of all are practices such as changing to a less intensive land use with lower probable returns.

The circumstances of economic privation and penury of a great majority of peasant farmers, in the "Third Word" in particular, make them too insecure to abandon traditional practices in favor of new, and to them, unproven practices. They do not have reserves to depend upon if the new practice should fail. In such circumstances, and where investment is required to control erosion, little can be achieved without external financing and guarantees against failure. This calls for government involvement. *Short-term tenancy promotes another form of insecurity that prevents the adoption of many desirable conservation practices.* It discourages longer-term investment and invariably results in land deterioration. *Regrettably, such land ownership patterns are most common in parts of the world where erosion is most severe and food demand greatest.*

In other circumstances soil erosion is overlooked and preventive action not taken because of two intrinsically human failings – ignorance and apathy. While ignorance may be eradicated by effective educational programs, apathy, to the present and, more important, to the future, is a more pernicious trait to extripate from the human condition. While some aesthetic and cultural obstacles to erosion control practices do exist i.e. plowing straight up and down the hill, they are minor in comparison to the others.

HISTORICAL PERSPECTIVE ON SOIL EROSION IN LEBANON AND THE MIDDLE EAST

In view of the growing global awareness of the insidious nature of soil loss through erosion and degradation, with its attendant adverse effects on both agriculture and the environment, and its social, political, and economic implications, it is pertinent to examine the historical development of this phenomenon so that mistakes or abuses in land management by past societies may be avoided or mitigated in future. This awareness, in the U.S. in particular, has spawned scholarly enquiries into the subject such as that of Carter (1974) who linked land use with the changing fortunes of civilizations. The foregoing discussion draws heavily upon this source, particularly with reference to the Mediterranean and Middle East regions.

Agricultural historians commonly attribute the beginning of accelerated erosion to the establishment of man in settled farming communities about nine thousand years ago. By continous cultivation in the environs of the settlement man began to upset, albeit unwittingly, the delicate balance between soil resources and the environment. What had taken hundreds of thousands of years to evolve from geological materials could be eroded in a fraction of that time. Historical records show that civilized man, with few notable exceptions i.e. Nile-valley, Mesopotamia and the Indus valley, were never able to continue a progressive civilization for more than one or two thousand years in any locality.

The connection between the decline and fall of such civilizations and despoilation of man's environment seems to have gone unnoticed by most historians who invariably attributed it to climatic change, war, famine or pestilence. Careful scrutiny of these arguments tends to dismiss such explanations as factors in the demise of civilizations. *While most writers note that powerful nations are those with abundant natural resources, they fail to note that many poor weak nations once had plenty. They are poor today mainly because their ancestors wasted the natural resources upon which present generations must live.*

Regardless of the forces that stimulate cultural progress, both civilization and the enjoyment of civilization depend upon a surplus production by those who provide the necessities of life. The primary producers must generate surpluses before artisans, engineers, philosophers, writers and artists can exist and function. Furthermore, a stable and continuous supply of food and fiber surpluses is necessary if civilization is to advance. Without this there could be no cities – the focal points of man's development. The earliest civilizations were dependent on irrigation, primarily because it guaranteed such a reliable and continuous food supply. Man learned the art of irrigation about 8-9000 years ago before he could read and write and before the era of extensive trade and developed political institions.

The civilizations that developed in the river valleys of the Nile, Indus and the Tigris-Euphrates 4-5000 years ago shared common features: the soil was fertile; water supply for irrigation was dependable; and the soil did not wash away because the land was relatively level and the rainfall scant. When these civilizations spread to more sloping land where rainfall furnished water for crops, a new situation was encountered. *As hillsides were deforested and subsequently overgrazed, the fertile topsoil began to be washed away. The land was ruined for farming in a few generations.* Consequently civilizations declined or persisted for only a few centuries, as they depleted or exhausted the lands upon which they were built. Across Asia and North Africa lie the remnants many former cultures i.e. western Iran, where the Meeds and Persians prospered; northern Iraq, the former home of the Assyrians; Syria, Lebanon, Palestine, Algeria and Tunisia, Greece and Italy which once supported great civilizations. While many cultures had their cities razed by conquering hordes and their populations decimated, one incontrovertible fact remains: *while the soil and other resources that built the cities remained, the cities and their civilizations were usually rebuilt.* Where resources were destroyed a resurgence in the civilization was virtually impossible.

In the ensuing sections brief reference will be made to the history of man's use of his land in countries of the region to which this document addresses itself – primarily Lebanon, and the countries of the Arab world i.e. Syria, Iraq, Palestine, Egypt and those of North Africa. For detailed discussion on any of these, the reader is referred to the original source.

Lebanon

As civilizations spread from the valleys of the Nile and Mesopotamia to the shores and islands of the Mediterranean man encountered a different environment: one that relied on rainfed agriculture in sharp contrast to the permanent agriculture based on irrigation which he had developed. There he learned of the erosive power of torrential rain falling on bare sloping land, but he failed, by and large, to develop the means to control erosion.

The Minoans of Crete built a civilization based on rainfed agriculture about 2500 B.C. Their civilization apparently grew and prospered for about 11 centuries, then declined and disappeared in two centuries. Today, nearly two-thirds of the island is a stoney waste; erosion has stripped most of the soil from almost all the sloping land. Poor by world standards, Crete now can support less than the population it had in 1400 B.C. The evidence suggests that depletion of soil resources had largely taken place prior to the decline. Had Crete retained her soil and natural resources that lifted her to such pinnacles of power and wealth, she would not have been obliterated as a civilization.

The story of Lebanon is similar to that of Crete but more is known about it. There, the history of land use and problems of both over-population and diminishing resources manifested themselves with tragic consequences. The Phoenicians, who inherited a cosmopolitan culture linked with Mesopotamia, Egypt and Crete, became the foremost merchants, traders, and seafaring people of the known world from about 1000 to 500 B.C.

The homeland of the Phoenicians consisted of a relatively narrow coastal strip merging into the foothills that rose steeply into the Lebanon mountains. These areas undoubtedly had fertile soil and sufficient rain to produce cereals, grapes, olives and most other crops grown by the ancients. Before crops were grown by man, nature grew lush crops of grass and forests, including the famed cedars of Lebanon. The demand for timber for building in the treeless plains of Egypt and Mesopotamia, and for their own ships, gave impetus to lumbering of the forested hills and mountains. The narrow coastal plain soon became inadequate to sustain the growing population. Cultivated fields took over from formerly forested slopes. By any standards, because of the steepness, these slopes were unfit for cultivation with severe erosion hazards.

However, the Phoenicians were not easily defeated in their fight against nature. They had plenty of stone on the cleared hillsides and made unique and profitable use of it in the construction of rock walls across the slopes – the first known bench terraces in history. Some of these terraces are still cultivated today, more than three thousand years after they were built, while the ruins of many more are visible. Faulty engineering, the power of cloudbursts, and the lack of repairs led to the failure of many of the formerly terraced slopes which are now eroded to bare rock. Food production might have been adequate to maintain a moderately prosperous civilization if all the cleared land had been protected by terraces – unfortunately only a small fraction of it was. The desolation of Lebanon can be linked, partly at least, to the ubiquitous and omnivorous goat of the nomads. Where forests might have recovered to protect the soil, prevent floods, and provide a continuous economic asset, the scavenger goats prevented such regeneration.

By the 9th century B.C., the Phoenicians found that lumbering, industry, trade and a meager agriculture were inadequate to support their population. So began the colonization of lands on the perimeter of the Mediterranean – with the establishment of Carthage as a major colony. During the 8th to the 6th century B.C. Lebanon had its golden age. While lumbering, trade, and commerce flourished mainly in the port cities on the coast, the land was so impoverished at that stage that it afforded little more than a subsistence living for the farmers and goatherds who occupied it. When conquering armies came through the mountain passes, tributes were levied on the wealthy merchants and shipowners – with scant attention given to the rural population. Finally, when Alexander the Great conquered Lebanon and destroyed its principal city of Tyre, Phoenicia began to decline in importance.

By the time of its decline, most of Lebanon's forests were gone, and the remaining trees disappeared within a few centuries under Greek and Roman axes although edicts of Hadrian show an early attempt at forestry conservation in the 2nd century A.D. *Today, all that remains is two lonely groves of the once majestic cedar, a grim reminder of man's folly towards the land and nature, and mute testimony to his greed and propensity for desecration of the very resource he depends upon-the soil.*

Other Countries of the Fertile Crescent

While no attempt is made here to even outline the history of these

areas, only rudimentary sketches are made of the role of soil erosion in relation to their respective developments. Mesopotamia, the modern area of Iraq, encompassing the fertile valleys of the Tigris-Euphrates rivers, probably contributed more to the advancement of civilization than any other area in the world. Its civilization represented a brilliant chapter in world history despite the fact that it had been overran by many tribes and races who, in turn, lived there. Erosion was not a problem in lower Mesopotamia, but rather that of keeping the network of irrigation canals free of silt which originated from the erosion of the Armenian hills in the rivers' watershed. For at least 20 centuries, the inhabitants in the lower reaches of the Euphrates succeeded in this task. The watershed may have been still fairly well covered with forest and grass and thus yielded lower quantities of silt than in later times. Since then the volume of sediments carried by the two rivers was such that 130 miles of the Persian Gulf was filled in i.e. 100 feet per year.

Under Babylonian rule, Mesopotamia reached its zenith with the most extensive system of irrigation canals known at the time. (Indeed, articles of the Hammurabi code contain injunctions against neglect of the irrigation canals). The main irrigation canals were lined with burnt bricks and the joints were sealed with asphalt. The 10,000 mile system supported 15-20 million people. The bounty of the land set the basis for magnificent palaces and temples, paved streets, art, writing, mathematics, astronomy and an advanced code of law. Despite successive onslaughts by the Assyrians, Persians and the armies of Alexander, Babylon was to continue for some time to flourish unlike the Assyrian civilization at Nineveh in the north, which did not have the resources to sustain it. However, Babylon also passed into oblivion when its canals succumbed to the silt, soon to be covered by the shifting desert sands and forgotten for two thousand years till it was discovered by modern archeologists.

Subsequent invasions of Mesopotamia by the Seljuk Turks and the Mongols not only ravaged the land but deliverately wrecked irrigation canals. Changes in the political fortunes of the Mesopotamians meant that the clearing of the canals, was abandoned. War was a major contributing factor to the disruption of the process of clearing silt from canals. The primary source of the problem lay in the rivers' headwaters over which the rulers of Mesopotamia had no power. The other factors which contributed to the decline of irrigated agriculture in that area are of a secondary nature. *The story of Mesopotamia is one which highlights the* *destructive action of deposition of erosional debris rather than removal of soil from its original site.*

Syria presents somewhat of a different picture with respect to erosion than either Lebanon or Mesopotamia. Its semi-arid climate helped, to some extent, to preserve the land from destruction by farming. Also, the broader valleys and comparatively level highlands did not erode as easily as did the steep slopes of Lebanon. Another factor which preserved the land was war. As conquering armies surged back and forth across the land, farmers were routed and their lands left uncultivated or ungrazed for generations at a time. While Syria has been a durable home for civilized man for three thousand years or so, its list of conquerors seems endless. Syria reached the height of its prosperity during Roman times when both agriculture and trade prospered. Land use pressure soon brought about severe soil erosion: it had a population of about 9 million then. The situation deteriorated further under Byzantium, and by the time the Arabs came, many fields were ready for abandonment. The Arab and Mongol occupations with their dry-land farming and grazing herds prevented the abused land from recovering.

The evidence of extensive erosion in Syria is compelling. Today, archeological excavation has shown that the once famous city of Antioch lies buried by up to 28 feet of silt. The ruins of about 175 towns and villages in the Plain of Antioch testify that it was thickly populated in ancient and medieval times – only 7 inhabited towns existed there in the 1930's. Much of this area is covered by leached-out erosion debris from the highlands. The ruins of many towns are covered by wind-blown dust and sand from cultivated fields. Soil erosion was at its worst in the area between Aleppo, Antioch and Hama where the rock base indicates the depth of eroded soil. The ruins of Palmyra and Jerash provide even more impressive proof of the destructive power of erosion. Those of the Nabatean civilization in Petra and in Arabia show how extensive the phenomenon was.

The story of erosion is much the same in Palestine as in Syria. Numerous references are made in the Bible to the agricultural riches of this area. This was all changed by the inexorable laws of nature aided unintentionally by man. The most severe erosion has taken place on the hillsides which are now bereft of topsoil – this devastation is irreversible. While much has been done to restore degraded land and apply modern conservation practices, it is overshadowed by the magnitude of past destruction. The so-called "promised land" as it is today, is a sad commentary of man's stewardship of the earth.

Egypt and North Africa

In this lands that fringe the southern Mediterranean, one finds civilizations that have defied the norms seen elsewhere, as well as some that declined and those that went into oblivion. Here, as in so many other cases, their fortunes were linked with land use. The valley of the Nile – modern Egypt – is the exception to the rule that civilized man can only prosper in a given area for a limited time. The durability of the land, which made thousands of years of prosperity possible, was due mainly to the unique features of the valley. The annual floods of the Nile, along its narrow valley, carried rich sediments and humus which originated far away in the highlands of Abyssinia and Central Africa. The thin layer of material was adequate to replace the minerals harvested in crops and thus ensure continued cultivation. This was achieved by a system of embankments which allowed the flood water to be trapped. After the silt load was deposited, and the soil saturated, the excess water was returned to the river. If the silt load had been as great as in the Tigris – Euphrates system, and the irrigation canals as extensive, it is likely that the same fate would have befallen Egypt. *While it is true that Egypt ran the gamut of conquering and being conquered and its civilization at times regressed, it did persist due to the fact that the fertility and productivity of its land persisted.*

A number of developments in the 20th century are disquieting in their implications for Egyptian agriculture. While the construction of the Aswan Dam and others on the upper Nile has controlled flooding and provided possibilities for generating more electric power and expanding irrigated land, the loss of fertility through less silt deposition, and salinity development associated with irrigation, cannot be discounted. The fertility loss has to be compensated by chemical fertilizers. The long-term effects of the loss of deposited organic matter have yet to be assessed. At present, sediment deposition behind the Dam threatens to reduce its capacity and indeed its ultimate viability. The principal reason is the increased deforestation, overgrazing, and farming of steep slopes in the headwaters of the river. Whether civilized man will continue to survive for another five thousand years will depend on how he has learned to work with nature rather than against it.

The countries that border the Mediterranean provide a striking example of man's destruction of his environment. While Egypt was an exception to this rule, the rest of North Africa was not. The reduced circumstances, by today's standards at least, of the countries of this region are in stark contrast to the hey-day of Carthage, in modern Tunisia, and when North Africa fed the Roman empire. The skill of the farmers in these times and the richness of the land was reflected by the 28 volumes of Mago's agricultural works which were a treasurehouse of information on the culture of grains, olives, grapes, figs and other crops. Subsequent population pressure and the necessity to give tribute in kind to Rome lead to the encroachment of farming in the drier areas to the desert and the exploitation of unfavourable hill land. Despite the elaborate system of aqueducts, water erosion began to take its toll as well as a relatively new phenomenon – wind erosion. The inevitable deterioration of the land was evident from the writings of St. Cyprian who lamented the failing crops, the drying springs and the general decline in productivity in the whole Mediterranean area.

The impact of warfare and invasion on the agriculture – and thus land use – in North Africa cannot be ignored. The extensive olive plantations of the Tunisian plain remained for a long time, and the surviving groves are an important part of the landscape, but as the Arab bedouin and their Berber allies had little respect for any tree except the fig and date, the olive trees gradually disappeared, probably cut for firewood or to punish farmers for failure to pay taxes. The disappearance of the trees made way for soil erosion as did overgrazing by sheep and goats of ranges that were bedeviled by the erosive winter rains of the Mediterranean area.

That the ancient city of Utica at the mouth of the Begradas river, which drains several million acres of formerly cropped and grazed land, lies today beneath 30 feet of sediments suggests the magnitude of soil erosion. The same fate too awaited Timgad, in Algeria, a city which was lost to knowledge for 1200 years, buried by dust – the product of wind erosion. A wretched village of mud-walled houses sheltering a few hundred inhabitants is the only descendent of this center of Roman power and culture. The "granary of Rome" is a sorry sight today. The distinguished soil scientist W.C. Lowdermilk, who cast his discerning eye on land-use problems in the Middle East region, commented "North Africa bristles with the astounding ruins of opulent and populous cities..." and "Ruins of the land are as impressive today as the ruins of the city.

The hills have been swept bare of a soil, a story which might be read throughout the region" (Carter, 1974 p. 119).

The chronicle of land mismanagement is the same in other areas that border the Mediterranean i.e. Spain, Italy and Greece. Indeed, the story of erosion can be told in every continent; the overgrazed east African highlands or the slopes of the Andes and the Himalayas (see Time magazine, September 12, 1977). Erosion – the forerunner of drought – helps the inexorable march of deserts at the expense of agricultural land. *In all cases, it is the result of an unfortuitous combination of circumstances that lead to the removal of soil – that precious resource – from a place where is sustains plant growth to places where it is useless or worst still, does damage. While it is tempting to apportion blame to a particular society or another or to a particular period within any given culture or civilization, this does not address the basic truth that man and society collectively has been responsible. All we can do today, in order to survive for tomorrow, is to learn from the mistakes of the past and to apply modern science to redress them and obviate such mistakes in the future. The historical imperative is ours.*

REVIEW OF EROSION-CONSERVATION STUDIES AT A.U.B.

An examination of the literature on land use in Lebanon reveals several disparate sources which vary in depth, scope, location and indeed, purpose. These sources include Government agency reports as well as those of international and philanthropic agencies, theses, a few published papers in referred journals, and soil survey reports. *The need to bring these sources of information together as a basis for charting future land management strategies is obvious and indeed pressing.*

By virtue of the Agricultural Research and Education Center being the principal location for field studies in A.U.B.'s Faculty of Agricultural and Food Sciences, most of the reported conservation-related studies have been conducted there on various aspects of soil erosion and its control. These topics are dealt with separately in summary form, and mention will be made where the results have been published.

Runoff and Soil Moisture

The relationships between precipitation, runoff and soil moisture with different land and crop parameters were studied by Shahlaee (1968) over a 2-year period. The variables were rainfall (rain depth, kinetic energy, and erosion index – EI30), percent slope (2.5, 3.5, and 4.5), slope length (30 and 60 meters), and crop cover (wheat, fallow, and vetch).

Runoff averaged between 1.5 to 4.0% of total precipitation with no significant variation between the two years. The parameter of rainfall which was most closely related to runoff was the erosion index, while rain depth was least correlated. Runoff was not affected by the percent slope, while runoff per unit area was 50% greater in the longer plots. The different crop covers did not substantially influence runoff. The study also showed that fallowing – a common practice in semi-arid regions – did not have any advantage in conserving soil moisture in two of the three years where observations were made.

While the study showed that runoff was minimal under conditions at AREC, and that therefore no particular conservation measures are necessary, the results certainly cannot be generalized to situations where there is a much higher degree of slope as in the foothills and mountains.

Coarse Fragments and Erosion

The relationship between the influence of coarse material – gravelly and very gravelly – distributed on the surface of plots (6.6 x 22.1 meters) with different slopes (2.5, 3.5, 4.5 and 9.0%) with runoff was studied by Sabir (1968). For the control plots, all fragments greater than 2.5 cm were removed and scattered on the treated plots.

Even though runoff from the plots was low i.e. 3-4%, the gravel on the soil surface tended to reduce it as well as reduce soil loss. This effect was accentuated with increasing amounts of gravel. However, soil loss was not proportional to the amount of runoff. The results of the study have no meaningful implications for erosion control. Although it may be nature's way to protect soil from further erosion, it is hardly likely that using gravel mulches would be practical in normal land management.

Nutrient Losses by Erosion

The removal of plant nutrients by runoff, either in soluble form or attached to part of the erodate, has been the subject of studies by Ahmad (1968) and Malik (1972): The first study involved three representative soils (a red Terra Rossa from near Khader village in the central Beka'a valley, a Chestnut – brownish soil from AREC, and a shallow Rendzina soil from the anti-Lebanon foothills) which were placed in micro-plots of 2 x 0.5 meters. Other treatments included fallow, straw mulch, and barley on these soils with 8 and 16% slope.

Nutrient loss, after water was applied with artificial sprinklers, differed significantly between the soils and was reduced by the barley in

contrast to the straw and fallow treatments. As expected, nutrient loss was greater from the 16% slopes. Nutrient loss was selective; the eroded soil contained up to four times as much organic matter and N as the original soil. Similarly, more available P and K was removed than total forms of these elements; losses were reduced by crop growth. Trends for micronutrients were similar though less evident.

The implications of this study are self-evident: erosion is a process that removes valuable plant nutrients as well as soil. Not only does this cause environmental damage i.e. eutrophication of water bodies, but it adds to the costs of production by requiring more fertilizer use. The solution is to apply fertilizers only when the land is cropped. Top-dressing should be done if possible after heavy rains and when the crop is in active growth.

The work of Malik (1972), using larger plots – 22.1 x 6.7 meters – on the erosion study site at AREC, confirmed the selectivity of loss in available N and organic matter. Loss of P and K was also selective and related to the clay content of the erodate. However, loss of total Mg, Fe or Mn was non-selective in contrast to Zn which was selectively removed in the organic matter fraction. Total plant nutrient losses were related to soil loss and to the degree of slope. These findings, again, confirm the importance of proper fertilizer management in order to minimize losses.

Mulches and Soil Erosion

Using the same plots as Malik (1972) and having varying degrees of slope i.e. 2.5 to 9%, Chaudhary (1973) evalated the effectiveness of a straw mulch at 0.5 and 1 ton/ha. Runoff was reduced by the mulch and decreased as the rate of mulch increased. Loss of nutrients was selective as had been observed by both Ahmad (1968) and Malik (1972). *The implications of this study for practical soil management are that erosion and runoff from agricultural land can be reduced by leaving crops residues on the soil surface, especially for the winter when the heaviest rains fall.* Thus, burning or removing the crop residues after harvest should be avoided.

Soil Loss Prediction

This topic was the subject of three theses (Yazdanian, 1969; Pissourios, 1970; and Haddadin, 1975). Although the work of Pissourios (1970) was supervised by A.U.B., the actual field work was conducted in Cyprus. Thus, it is of interest to compare findings from there with those of Yazdanian (1969) and Haddadin (1975) at AREC.

Yazdanian's (1969) experimental variables were rainfall factors (amount, kinetic energy, erosion index, and momentum), slope degree (2.5 to 9%) and length (22 to 60 meters), and cropping systems (fallow, wheat, vetch). The principal conclusions were: the erosion index was the best predictor of soil loss while rainfall momentum was best for runoff; the crops used decreased soil loss but had little effect on runoff; runoff was closely related to slope steepness. The AREC clay soil was shown to have a high resistance to erosion with an erodability factor of 0.169. The *implications are that, where the erosion index of rainfall is known and is high, soil loss can be minimized by cropping and by reducing landslope by terracing and gradling.*

Haddadin's (1975) study related soil loss from these plots with erodability factors using multiple regression analysis. There was a poor relationship between actual soil loss and loss predicted by the Universal Soil Loss Equation. No single variable was suitable for predicting soil loss. When all variables were combined in the non-linear multiple regression analysis model, $CaCO_3$ had the best predictive value. Permeability was negatively related to soil loss. The practical implications of the study are that soil loss could be reduced by improving water penetration and movement through the soil. Further research is obviously needed to reconcile the conflicting results obtained for the Beka'a valley with those obtained elsewhere.

The study of Pissourios (1970) involved establishment of numerical values of the Universal Soil Loss Equation i.e. erosion index, erodability, and crop management factors in various regions of Cyprus. Soils with slope gradients greater than 6% had soil erosion losses greater than allowable limits when these soils were farmed with no erosion control practices. Terracing and contouring were effective in reducing soil loss. Cultivation on slopes greater than 16% resulted in soil loss greater than permissible limits even with contouring and terracing. The implications of this study for Lebanon where rainfall factors are similar would be that cultivation on such steep slopes is detrimental and should not be allowed.

It is important to realize that erosion may occur even on gentle slopes i.e. 2-5%. These are the maximum permissible values in the USDA Land Capacity classification system for Class I and II, respectively. Conservation measures should be taken in Class II land in order to minimize the slope effect i.e. contour tillage, strip cropping etc. The permissible limits of slope for Classes III and IV are 8 and 12%, respectively; these slopes require contour and bench terracing. Since erosion and degree of slope are exponentially related, slopes greater than 12% should not normally be cultivated.

Cropping Systems and Soil Properties

Azizi (1972) and Paeth and Azizi (1974) examined the cropping history of two soil types at AREC in relation to selected soil properties. Soils with rotations that included alfalfa, or on which perennial forage was grown, contained more organic matter and N, were better aggregated, had lower bulk densities, and had higher water-holding capacities than soils with a rotation of annual grains and fallow. As organic matter increased, there were corresponding increases in aggregation and available water-holding capacity and a decrease in bulk density. Irrigation accentuated this relationship. *Thus, for the semi-arid regions of the Middle East, the importance of including legumes and forages in rotational crop systems is obvious.*

Soil Structure Factors

The significance of organic matter, iron oxides and calcium carbonate on soil aggregation were evaluated in a laboratory study (Arshad, 1975; Arshad *et al.*, 1980). In five soils from the Beka'a valley organic matter had a consistent effect on aggregation while iron oxides improved aggregation only when they occurred as discrete forms. There was no effect of calcium carbonate. Again, the study underlined the practical importance of maintaining adequate organic matter in the soil in order to preserve its productivity and reduce erosional losses.

Implications of Deep Plowing

In view of the common practice in Middle Eastern countries of deep as opposed to shallow or conventional plowing, the subject was addressed by field (Mojaddadi, 1977; Malik, 1974) and pot (Ansari, 1974) studies. *The general conclusion from these studies was that the practice had no beneficial effect on soil structure or the fertility status of the soil – in fact, adverse effects were observed on plant growth.* This can be explained by the fact that deep plowing, by bringing less fertile soil low in organic matter to the surface, reduces organic matter and fertility of the topsoil which mainly sustains plant root growth. The implications of *this practice for soil erosion are that it promotes rather than reduces erosion* by virtue of its effect on organic matter and therefore soil structure, and plant growth which is a major factor in erosion control. These conclusion coincide with a recent up-to-date assessment of deep tillage by Troeh *et al.* (1980). In essence, deep plowing is likely to be of benefit only when there is a physical or chemical layer at some depth which impedes root growth. This can be easily ascertained from soil survey information and by observations of the soil *in situ* in a pit or by use of a sampling auger.

LEBANON'S GREEN PLAN: ORIGIN, PHILOSOPHY AND ACCOMPLISHMENTS

Soon after its independence in 1943, both the depressed state of Lebanon's agricultural sector and the potential for development of the rural community were apparent. At that time, only about half of the land or 0.6 million hectares was suitable for agricultural use; of this, only about 324,000 hectares were actually under cultivation. Some 300,000 hectares of potentially suitable agricultural land lay fallow, neglected or abandoned, including 71,000 hectares of crumbling hillside terraces, hand-built over past centuries.

Forest land, principally because of uncontrolled grazing by goats and manufacturing of charcoal, had shrunk from an estimated 271,000 hectares (roughly 25 percent of the country's surface) to 73,000 hectares (about 7 percent). Ideally, about 18 percent is needed to maintain a healthy ecological equilibrium of water, soil and climate.

It was obvious to everyone – Government, agronomists, farmers and sociologists – that extreme measures were needed to try to reverse these dangerous trends before the country's agricultural problems grew to the extent that they harmed development and progress in such other areas as industry and commerce as well.

Thus, with UN/FAO help, emerged the Green Plan in 1964; an autonomous authority of the Lebanese Government for agricultural development. Its many basic, but ambitious goals were: to study the existing situation, to survey markets for future produce, to reclaim farm land, to grow and distribute new plants, to develop pasture land to reforest. These projects, together with a strong infrastructure of irrigation, electrification and road schemes implemented by other Government departments and agencies, were designed to ensure an economically viable rural sector which contributes its share to the national economy.

One of the first projects was a general scientific survey of land capability, an on-the-ground reconnaissance of the potential adaptability of the land to agriculture. The results. of this study were recorded on a 1/100,000 scale map, the only map in print which provides such vital information for the development of agriculture in Lebanon. This was followed by a general census of livestock, the only such survey ever carried out in the country, providing details on the breeds and locations of all Lebanon's livestock resources. For the first time in Lebanon or elsewhere in the Middle East, a detailed inventory of forest vegetation was made, based on actual site surveys and a census of the forest stands which were later correlated with aerial photographs. These data enabled Green Plan personnel to prepare two more maps (1/50,000 and 1/200,000) which included the area of the forests and information on the density of stands and species of trees.

With such basic research tools in hand, the authority could proceed with development studies. First, as a means of showing what might be done eventually over the entire country – given money and time – the Green Plan selected two underdeveloped regions, one in the district of Batroun and one in the district of Hermel, to prepare regional integrated development schemes. It undertook both a general and a complete survey of the regions to serve as a basis for drawing the integrated plans. These not only included such agricultural aspects as plant and animal production, and water supply and distribution, but also such complementary aspects of regional development as sanitation, medical, public services and transportation.

Traditionally in Lebanon, religious communities have often held land acquired by gift or purchase through the years to finance charitable works. Since much of this land had been allowed to remain unproductive, the Green Plan volunteered a development scheme for "wakf" and communal properties.

After a general survey, the authority established integrated development plans which included sanitation, education and industry, as well as agriculture. Also, feasibility studies were made for specific projects to help interested groups build future development on sound ground.

On a more complex level, the authority prepared a national plan for agricultural development. This plan reported the prevailing situation of agricultural production and land productivity as well as the potential for

land improvement, with a scientific projection for the coming decade, all-important if agricultural development was to be given its proper place within the framework of the nation's general development policy.

Lebanon's Green Plan experts thus gained valuable field experience which soon made itself useful in a neighboring Arab country. This was in response to a request of the government of Iraq, the Green Plan sent a team of specialists to compile a complete study for regional integrated development of northern Iraq, similar to those already completed for the two smaller regions of Lebanon. The finished report appraised the socio-economic situation and prospects of the region and outlined a proposed two-year emergency program as well as a plan for long-term action. The comprehensive program included suggestions for road networks, urban planning, public housing, a campaign against illiteracy, hospitals, preventive medicine and anti-pollution measures as well as agricultural projects. In that basic area, the report recommended schemes for land reclamation, water supply and distribution, mechanization, animal production (including the introduction of new breeds), forest and range management, the establishment of agro-based and other light industries. For its part, Iraq responded by approving in principal, a budget of $200 million towards implementing the recommendations. The Green Plan set about establishing a framework of strengthening technical cooperation between Lebanon and Morocco.

With initial maps, studies and plans completed, the Green Plan was ready to execute actual rural development projects in the field. In this respect, one of the most visible projects was reclamation of privately owned land, principally through terracing hillsides with bulldozers provided at cost by the Green Plan, or by finacing work by loans of cash or food. Nearly 16,000 hectares have been developed or reclaimed since 1965. Before loans are arranged or work begins Green Plan experts do soil tests and economic feasibility studies. The amount of aid given to any one landowner was limited and geographical distribution throughout the country was maintained.

Reforestation and watershed management was another major effort, as was rural road construction. Nearly 20,000 hectares have so far been reforested around the country, primarily for long-range erosion control. Unpaved but carefully designed roads were built into potential agricultural areas in order to serve the small-farmer communities. Historically, some land in rich, well-watered valleys has lain fallow simply because of the difficulty of moving produce to market up steep, narrow donkey trails. The Green Plan has build countless new rural roads, totalling more than 800 kilometers.

In areas where the soil is suitable, Green Plan engineers have scooped hundreds of earth reservoirs from hillsides to collect and save the usually adequate winter rains and spring runoff from high-altitude snows. They have also undertaken studies for water canalization and distribution. Other specialists have drawn up designs and plans for basic farm structures such as barns, poultry houses and silos, and have supervised their actual construction on privately owned lands.

With terraces ready to plant and sufficient water to irrigate them, priority shifted to providing plants and seedlings to Lebanese landowners. The Green Plan established three nurseries for the production of fruit and forest trees as well as some ornamental shrubberies; over one million trees were produced annually for distribution at cost to farmers. At the request of the Beirut municipality, the Green Plan helped in establishing several public gardens and in city landscaping. On the national level the Green Plan began work on a major park with an international character in a suburban Beirut pine forest, and a national park and nature reserve in the region of the venerable cedars of Barouk.

One unusual aspect of the Green plan's work has already drawn wide praise from world authorities in two seemingly unrelated fields: agriculture and law enforcement. Formerly in certain arid and isolated areas of the country Indian hemp (more commonly known as marijuana), though illegal, was in fact, the major cash crop. In response to a worldwide campaign to control cultivation of the plant, Lebanon, through the Green Plan, has actively encouraged and trained farmers in these deprived areas in the introduction of new crops, principally, the sunflower, valuable for its oil and protein-rich seeds. (Though the search for technically and economically substitute crops has not been abandoned, as a result of the circumstances in Lebanon since 1975 marijuana has again become a major crop).

With a basic infrastructure of research data and capital works rooting Lebanese agriculture firmly in the present, the Green Plan extended its horizon in the early 1970's and looked to the future. Taking Lebanon's strategic geographic position into consideration, the authority's

experts experimented with winter vegetables for Euopean and Arab markets in model greenhouses. A sophisticated pilot hydroponics unit, was installed to demonstrate the most modern techniques to Lebanese growers. Economic and technical studies as well as staff training went on in the fields of sprinkler irrigation for fruit terraces. Other developments included more extensive farm mechanization and the establishment of agro-industries (such as the canning of apple juice and other products).

The tragic circumstances of civil disruption that have plagued Lebanon since 1975 have taken their toll on the operations of the Green Plan. Indeed, few institutions in either the public or private sectors have escaped being adversely affected. *Though a re-orientation of its program's priorities is inevitable as a result the war, the rationale and need for the Green Plan, are, today, more crucial than ever.*

OTHER LAND USE-RELATED STUDIES IN LEBANON

While several miscellaneous studies have been made on land use in Lebanon, the following reports are worthy of mention – one dealing with the range of land use problems and the other dealing with the significance of man's activities with respect to soil erosion in relation to soil development.

Ford Foundation Report

Various aspects of Lebanon's agriculture were surveyed and reported on in the mid 60's, by a team of specialists from the Ford Foundation. (Only a section of that report was available to the author; therefore the author/s, title and exact date of the report cannot be given). In the context of the present report, it is relevant to resurrect the observations and the recommendations contained in that study. Though nearly two decades have elapsed since its completion, its contents are more relevant than ever since the state of land use, in general, has declined in the intervening years. (Though it is likely that the statistics for type of land use and animal populations differ somewhat from those of today, the figures are reasonably close to more recent data by Andreou *et al.* 1979). As a preamble to the discussion of land use problems, the relevant background information is presented:

"In spite of its small area, Lebanon possesses a wide range of physiography. The five major divisions include a narrow coastal strip, the west (moist) slope of the Lebanon Hills, the east (dry) slope, the interior valley (Beka'a) and the Anti-Lebanon Hills lying east of this valley. *The physiographic pattern largely determines the diverse climatic, vegetational and land use patterns of the country.*

Climatically, Lebanon is more favored moisture-wise than many neighboring countries. Precipitation on the western side ranges from 600mm annually on the coast to 1,500 mm at the top of the Lebanon Hills. Even the driest areas, in parts of the interior valley and the Anti-Lebanon, have 400-500 mm of rainfall. The distribution is seasonal, with a dry season from May through October.

The soils reflect the topography, parent material and climate, and show striking differences, particularly between the relatively flat coastal and Beka'a regions compared to the mountainous areas. "The native vegetation has been so altered by cultivation, cutting and grazing that it is difficult to reconstruct the original situation." The total area now grazed actually includes much of the forest and some of the cropland, and totals about 85 percent of the whole country. "The grazing lands represent a particularly abused and diverse resource which includes untilled areas in all stages of deterioration, lands abandoned from cultivation, fallow, and depleted forest areas. No detailed range surveys have been made, but reconnaissance observations have indicated that most of the range would be classed in "poor" condition, with a small amount in "fair", and none in "good"."

"The major problems stem directly from the above conditions, and are as follows:

1. **Accelerated erosion is widespread and severe.** It is worst on the 150,000 hectares of abadoned lands and on the wildlands. Cultivated lands are eroded less, because many are level or nearly so, and most of the sloping areas are protected by terraces. The degree of erosion varies in different parts of the country, but in one of the worst portions on the Lebanon Hills east of Sidon, sheet erosion is severe on three-fourths of the area and gullies on one-third. Two-thirds of the total area was once terraced and cultivated, but half of the cultivated area has since been abandoned. The terrace system is in poor shape, with half those of medium width and almost all of the narrow terraces in poor repair. Sixty-four percent of the area is in wild or abandoned lands, yet this portion produces only 5 percent of the total revenue, and damage from grazing far exceeds the revenue received. The situation detailed for the Sidon are points up the main causes of the erosion problem. *These are: cultivation of steep areas; failure to maintain terraces or to revegetate abandoned land with soil-holding perennails; and persistent overgrazing of wild and abandoned land. Destruction of forests has been an additional factor in the higher zones.*

2. **Overstocking.** Stock numbers are far above the capacity of the ranges in their present depleted condition... The majority of the livestock, and particularly the goats, are poorly fed and produce far below their potential. Goats have been blamed for much of the overgrazing and erosion in Lebanon, but in reality they represent only the ultimate in overstocking and poor range management, since the goat can exist and produce better than cattle or sheep under extremely poor grazing conditions.

3. **Most of the forested areas, for which Lebanon was once famous, have been depleted by indiscriminate cutting and overgrazing.** These areas now produce little wood or forage and contribute greatly to erosion and flooding of lands at lower elevations.

4. **Poor utilization of abandoned crop lands.** These areas, although unsuitable for cultivate crops, could in most cases be reseeded to perennial forages and used for grazing and hay production. In fact, this measure appears to be the logical first step in solving the problem of livestock forage, and, in part, that of erosion.

5. **Poor range and livestock management.** As in most other countries of the Near and Middle East, the standard of range and livestock management is low. However, until the key problem of overstocking is resolved, the development of better grazing practices or introduction of better livestock is not feasible.

While the land management problems in Lebanon are severe, and the degree of soil depletion great, solutions to these problems appear less difficult technically than in countries with lower moisture potential. A nation-wide program should involve: *(1) revegetation of large areas of abandoned land and their subsequent utilization under a system of rational grazing; (2) replanting the forest areas of highest potential and excluding grazing and uncontrolled cutting; (3) construction and repair of of terraces on sloping arable lands of high potential; (4) restriction of cattle and sheep numbers to present levels, and reduction of the goat population. With better nutrition, it would be possible to increase livestock production even with decreased numbers."*

While the report mentioned the work of the Green Plan, it did stress the need for greater awareness and willingness at Governmental level to tackle this critical national problem of land degradation. Another major criticism was that "The agricultural program at A.U.B. is concerned almost entirely with cultivated lands and crops, however, and leaves a serious gap in the wildland management field. Funds recently received to establish a chair of soil conservation represent a first step in filling this gap, but leaves the vital areas of forest and range management still unsatisfied." Regretably, this position is currently defunct.

Soil Survey of Southern Lebanon

Verheye (1973) concluded a study on the formation, classification, and land evaluation of an area in south Lebanon of about 80,000 hectares bounded by the Awali and the Litani rivers and extending from the watershed line at 1500-1700 meters elevation to the coast. It is pertinent to present his observations on the influence of man on erosion, and its subsequent implication for the process of soil formation, as well as some of modern man's constructive activities in relation to soil classification:

"In a region which as been densely populated from time immemorial, it is obvious that the human influence on pedogenetic evolution cannot be denied. *In this respect, the destruction of the original forest vegetation can be considered as the most important feature...*

The result of this deforestation process is that, with the exception of some limited surfaces on sandstone substrata, the original soil cover of the southern Lebanon has completely been destroyed, a statement that can practically be generalized for the complete levantine coastal area. As a consequence, the erosion activity has been intensified, and the microclimate has, without any doubt, undergone a certain modification...

In a more recent period the human influence has mainly concentrated on the extension and improvement of the arable area. Along the slopes the farmers have built a dense network of terraces of different size and shape, making a maximum use of the local circumstances and possibilities... The influence of this small-scale soil improvement was however rather limited, and had, with some few exceptions, practically no influence on the normal soil evolution.

During the last decennium, important land improvement schemes have been carried out, mainly in order to extend and to intensify the citrus and banana plantations in the survey area. In the coastal plain for

example, the original alluvial and colluvial deposits have been intimately mixed with fertilizers, and so much soil material has been transported from abroad that these units have completely lost their original properties. On the other hand, huge levelling and land improvement works have been carried out in the western sector of the plateau area, making use of dynamite, bull-dozers, rippers and other specialized machinery in order to permit a better agricultural development of the region. Because in the latter case the original soil profiles have completely been disturbed and mixed with foreign soil material, these newly reclaimed surfaces were also mapped as man-made soils or Arents."

SOIL MANAGEMENT TECHNOLOGY TRANSFER

The concept of soil and water conservation is comparatively new: it began at governmental level in the US in the mid 1930's in response to the disasterous effects of wind erosion on the country's economy. Today, most countries have established some kind of soil conservation agency, most often based on the USDA-Soil Conservation Service model. The voluminous research literature which has emerged from the U.S., in the past few decades, has provided a basis for problem solving in the field. Much of the research was, and is, applicable to lesser-developed countries with some modification.

Technology transfer in soil and water conservation has been boosted by several concomitant developments. The increasing use of Soil Taxonomy (1975) as a basis for soil classification in many countries has provided a rational basis for communication between soil scientists. The potential advantage of this system has recently been reviewed (Cline, 1980). The Benchmark Soils Project of the Universities of Hawaii and Puerto Rico (Beinroth *et al*, 1980) adopts a similar approach i.e. accumulating research data and characterizing reference soils on a world basis and extending that information directly to areas where such soils occur. Various other programs are available to help developing countries. The Soil Management Support Services program of the US Soil Conservation Service and the Agency for International Development is an example of such technical assistance.

Progress in implementing innovations in soil management has, on a global scale, been variable. Failures have often resulted where new techniques were used without regard to soil conditions as well as to culture and farming patterns (Troeh *et al.*, 1980). An example has been the failure of massive mechanization schemes in the tropics – where soils are compacted to the detriment of structure and crop production capabilities. The concept of appropriate technology is now in vogue in soil management. The work of research institutes in developing countries i.e. the International Crops Research Institute for the Semi-Arid Tropics in India – ICRISAT, and the International Institute for Tropical Agriculture in Nigeria — IITA, has done much to adapt conservation techniques to local conditions.

At a more general level, other organisations such as UNEP/ FAO and the International Society of Soil Science have greatly contributed to the sharing of information on a global scale and to technical cooperation. Examples of two of these programs follow.

World Soils Policy

As a result of a UNEP/FAO meeting of technical experts in Rome in February, 1981, a basic framework for international action on soil and land use-related issues was drawn up (ISSS, 1981). Since few planners are aware of this policy, and since its implications are particularly relevant to Lebanon and the Middle East, the essential features of this policy are presented. It was defined as follows:

"In recognition of the fact that soil is a finite resource, and that continuously increasing demands are being placed on this resource to feed, clothe, house and provide energy for a growing world population and to provide worldwide ecological balance, *the governments of the nations of the world agree to use their soils on the basis of sound principles of resource management, to enhance soil productivity, to prevent soil erosion and degradation and to reduce the loss of good farmland to non-farm purposes.*"

Its objectives are:

- to increase and apply scientific knowledge of the soils of the world to their potential for production, and their sound management;
- to encourage and assist countries in improving the productivity and management of their soils and in reducing soil degradation;
- to encourage the management and conservation of soil, reduce pollution, and improve the quality of water and air.
- to develop and promote agricultural production systems that assure the use of the soil on a sustained basis;
- to enlarge and improve the world's supply of arable agricultural land through irrigation, food control, and reclamation;
- to slow the loss of productive agricultural and forest land to other purposes;

- to monitor changes in soil quantity and quality and in land use; and to bring to the attention of the people of the world, and their political leaders in particular, the extent of world soil degradation and its seriousness, its causes and its remedies.

It is addressed to:

- international and regional organizations, including UNDP, FAO and UNESCO, who will share in promoting and supporting the international and regional activities suggested;
- national governments and non-governmental organizations, without whose support the recommendations cannot be carried out;
- individuals who, conscious of their individual and collective responsibilities for safeguarding soil, water and related resources, are willing to lend support to the principles of a World Soils Policy.

The Plan-of-Action for the World Soils Policy was summarized as follows:

a) The appropriate international organizations should:

- Promote a sound use of land and water resources
- Continue and intensify efforts to create awareness of the necessity for rational resource use among all sections of the world community, including governments and non-governmental organizations; assist where required to provide training, to mount publicity campaigns, seminars, conferences and the provision of publications.
- Intensify efforts to promote optimum land use for sustained production on a worldwide basis and interregional and international cooperation in the use and development of land and water resources.
- Promote cooperation between goverrnments in adopting sound land use practices, particularly in the international watersheds.
- Encourage international development financing agencies to pay particular attention to the ends of agricultural development projects which include the conservation and improvement of soil and water resources, the provision of inputs and incentives at the farm level, and establishment of the necessary institutional structures as major components.
- Assist governments, on request, to establish appropriate legislation, institutions and procedures to enable them to mount, implement

and monitor appropriate land use and soil and water management programs.

- Encourage the expansion of bilateral assistance to developing countries in resources management from the developed countries, foundations, and other institutions.
- Help countries to improve their capabilities to assess the agricultural potential of their soils, to expand the wise use of fertilizers and to apply improved soil management.
- Select critical areas of resource degradation for application of experimental pilot programmes of resources improvement.
- Harmonize the collection and exchange of information on practical applications of soil research among international organizations and institutions, in particular:
  - i) promote the adoption of an international reference system of soil classification
  - ii) with a view of facilitating transfer of experience and technology
  - iii) develop simple soil capability classifications and land evaluation methods; develop common methodologies for monitoring soil degradation and changes in land use.
- As a final objective, incorporate the principles of national land use and the conservation and development of soil and water resources into a comprehensive international resources law, in the form of a World Soil Charter.
- Hold recommended regional meetings to consider world soil problems and suggest that the General Assembly of the United Nations convene a world conference on soils policy.

b) All national governments should:

- Commit themselves to the sound use of land and water resources.
- Develop a land use policy and the necessary legislative framework to implement it.
- Increase awareness among all sections of the community of the problems caused by the loss of productive soil and of the need for prompt action.
- Identify, map and assess the potentials and constraints of soil resources, map current land, use, assess the present extent of soil degradation, predict foreseeable hazards and develop methods for third prevention.

- Adapt soil capability classifications and methods of land evaluation to local conditions.
- Develop programmes to ensure the availability and wise application of fertilizers and other actions appropriate to the improvement and sustained use of the soil.
- Establish an adequate legislative andinstitutional framework for monitoring and supervising soil conservation development and management.
- Impose obligations on users, with the aim of ensuring the most rational use of land, through the use of tax exemptions, subsidies, credit facilities and other types of financial devices.
- Train an adequately paid professional cadre of extension workers to assist farmers in managing soil and water resources effectively.
- Establish and fund programmes, where needed, of reforestation, irrigation, and reclamation of saline, flooded or other land not presently productive.
- Actively pursue research needed to develop systems of farming that combine adequate production with resource protection and are compatible with socio-economic and cultural conditions.
- Help develop local institutions to secure the leadership, assistance and cooperation of farmers in applying soil and water improvement and conservation practices. Provide an adequate programme of environmental education in support of resource management activities.

In the document also some specific recommendations were made to UNEP, FAO, and UNESCO for future action:

- Strengthen the current effort of the United Nations system to assist the developing countries to set up national institutions for soil inventories and land evaluation. This should include the training of scientists in fields related to soil management and conservation.
- Establish a clearing house for the collection and exchange of information on the practical applications of soil research among international organizations and institutions.
- Support the establishment of the proposed International Board of Soil Resources Management.
- Support the development of an international reference base for soil classification.
- Support the preparation of guidelines and methodologies for prac-

tical land capability evaluation systems at the national level, on the basis of a global framework for land evaluation.
Support the development of methods for land resources monitoring at both global and pilot levels."

"Save Our Soils" Project

Another program of relevance to the current topic is one which arose from the considerable concern expressed at the U.N. Environment meeting in Stockholm in 1972 (ISSS, 1981). A working party was convened in 1976, by UNEP, the International Federation of Institutes of Advanced Study (IFIAS) and the Council of Ministers of the USSR, to enquire into the causes of soil degradation and the loss of productive soil. The purpose of the Working Party, which was held at Samarkand, was to enquire into what steps should be taken and what area of knowledge should be investigated in order to reduce or control this loss. Five causes of the loss of productive land were identified:

a) A progressive exhaustion of the plant nutrient supplying power of the soil, due to leaching of nutrients in drainage waters or to long continued removal of nutrients in plant and animal production.
b) The erosion and loss of topsoil associated with cultivation of sloping land and overgrazing of pastures in semi-arid, sub-humid and humid lands. This was associated with desertification in semi-arid areas, even on flat and gently sloping lands, and with restriction of cultivation by deep gullying in better watered areas;
c) By erosion associated with deforestation, associated with commercial timber cutting, extraction of firewood, forest fires, or shifting cultivation – particularly in the wet tropics;
d) Loss of production in irrigated areas due to salinization and water logging;
e) Absolute loss of land to agricultural activities because of the extension of urban areas, railways, airfields, etc.

The techniques for the control of these degradative processes, except the last, have already been worked out. They include the use of fertilizers to restore nutrients; the use of contour cultivation, strip cropping, contour banks and grassed waterways to control erosion on sloping lands under cultivation, the use of fertilizers and controlled grazing to

maintain a protective vegetative cover in grazing lands; the use of minimum cultivation and surface mulch to protect the soil surface against rain-drop action; the use of agro-forestry techniques to provide wood fuel supply and alternative income or food sources on land too steep for normal cultivation; and by drainage and control of water table depth in irrigation areas. For all these the principles are known, although they may need to be adapted to the needs of any particular environment.

As a result of their considerations, the Working Party set up a steering committee including representatives of FAO, UNEP, and UNESCO, which recommended that IFIAS should develop a project which would investigate the extent to which socio-economic factors were responsible for the failure to apply known technologies for the control of soil degradation in developing countries. The intention was to establish a cooperation with six to eight centers in the warm semi-arid and wet tropical regions.

The plan-of-action was to identify, examine the soil and biotic factors or constraints, which have been dealt with in this publication as well as the socio-economic aspects which are worthy of enumeration here: agronomic and water management practices; land tenure and farm size; population density and age pattern; available capital and credit, power available for cultivation (hand labor, oxen, tractors); equipment maintenance; marketing arrangements and transport facilities; source of fuel for cooking, etc., and lack of viable alternatives to present practices; traditional or religious restraints on what work can be done, or what animals kept; financial or legislative proposals associated with the new technology being acceptable to the village community; poor communication between officials and farmers; and technology appropriateness to soil and climatic conditions.

The program has involved the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) at Hyderabad, India, the International Institute for Tropical Agriculture (IITA) at Ibadan, Nigeria, and the International Fertilizer Development Center (IFDC) at Muscle Shoals, U.S.A., whilst the Centro International de Agricultura Tropical (CIAT) at Cali, Colombia. In each of the cooperating countries, a comparative study is also being made of land tenure, soil conservation, and forestry legislation. It is hoped that these studies will result in effective remedial action been taken.

CONCLUSIONS AND THOUGHTS FOR FUTURE ACTION

Based on the examination of the literature-both historical and current – one has to arrive at the conclusion that soil erosion has been severe in the past in Lebanon and the Middle East, and that the present situation is, indeed, far from satisfactory. There is, in addition, little evidence of any general awareness of the problem of land degradation and its implications for Lebanon's economy on the part of either agriculturalists, planners or the community at large.

For instance, in the agenda paper on agricultural development in Lebanon (Andreou *et al*, 1979), scant reference was made to soil erosion or land degradation; in fact, no mention is made of soil resources or soil conservation. Other considerations which were given little or no emphasis included; the role of grazing animals in promoting forest and range destruction and land erosion – a fact apparent to conservationists everywhere; the need for zoning of land for agricultural purposes based on the susceptibility to erosion i.e. land capability classification; and use of conservation measures in crop production. Though "new improved germplasm" has an appealing sound, its viability is doubtful unless combined with conservation farming and other essential agricultural inputs.

The review of specific erosion-conservation studies at A.U.B. provides conclusions more or less in accord with such studies elsewhere. Some of the findings were site-specific. A possible limitation is the fact that most of the studies were at AREC and as such were representative of part of the Beka'a valley and would have no relevance to other areas with steep slopes and heavy rainfall. However, the state of the art is such that once these topographical and climatic factors are known, one where reliable estimates can be made, it is possible to design and implement erosion control structures within a framework of land management based on capability classes. Further studies which focus on the fundamental nature of the erosion process are superfluous for Lebanon. *The need is for implementation of conservation measures.* Thus, it is possible to emerge with some thoughts for action in the area of land use management and to provide more specific recommendations as well. The more obvious ones are:

Planners and Educators

1. Develop the concept of land capability classification for Lebanon's land resources. As a result much of the land now in cultivation i.e. on steep slopes without erosion control measures, would be returned to grazing and re-forestation. Large areas of the country are only suitable for forestry. *Re-forestration is a matter of the highest national priority.* Such a move would be the basis of a future lumber industry, game reserves and recreational areas and, thus, the tourist industry.
2. Loss of what's left of Lebanon's valuable agricultural land to non-agricultural purposes i.e. buildings, roads etc. at such an unprecendented rate should be halted, and examined carefully in the light of development plans in the national interest.
3. The impact of sediments from soil erosion on deposition at mouths of rivers and along the coastline should be determined – and effective action taken.
4. The system of grazing allocation should be examined. No progress in improving range productivity or establishing forest plantations can take place without controlled rotational grazing by fencing or other means.
5. Erosion of rural roads cannot be further neglected. Apart from remedial measures, future planning should ensure that roads in mountainous areas are sited on the contour – thereby reducing rather than promoting erosion.
6. Though less extensive than surface erosion loss of land by stream-bank erosion as well as coastal erosion by the sea should be dealt with. The potential disasterous implications of the recent sand removal from the coast and road erosion have received recent publicity (Geoletter, Geology Dept., A.U.B., Winter 1981-82).
7. Though wind erosion is minor by comparison with water erosion in Lebanon, shelterbelts could be effectively used in exposed places i.e. along the coast, in order to protect soil and reduce wind damage to crops.
8. Because of the expense involved, no major earth-moving operation or terrace construction should be undertaken without considering

alternative land use options, making sure of adequate drainage, or evaluating the impact on the area.

9. Because the return on soil conservation projects is long-term, special credit arrangements should be made available to induce farmers to undertake such improvements.
10. Irrigation systems should be designed to minimize soil erosion – a frequently overlooked aspect – and prevent the buildup of salinity which contributes to land degradation.
11. Though most of Lebanon receives adequate total rainfall, most of it runs back to the sea. Conservation measures involving re-forestation of the watershed would greatly increase infiltration and groundwater recharge – thus obviating drought during the dry season.
12. While recognizing the limitations of government agencies in terms of personnel, equipment and information resources, it is vital that conservation programs in Lebanon be co-ordinated with those of international agencies in this area of endeavor. Specific recommendations for such cooperation were spelled out in the section on "World Soils Policy".
13. Attempts should be made to harness the latest available technology in the fight against erosion and environmental degradation i.e. the use of remote sensing to monitor Lebanon's land and water resources.
14. An awareness of the land and land use-related issues i.e. erosion, deforestation, overgrazing, pollution, wildlife destruction can be re-awakened in the people of Lebanon through the mass media. Suitable programs could be devised by communication specialists and aired on T.V. and radio. A new innovation such as the use of cassettes of pre-recorded program, as has been introduced by the Rockefeller Foundation in Turkey (Ceres, 1981), could be used to great advantage.
15. The future of Lebanon, and how its land is used or abused, lies with its children. The author suggests that an educational program, with school children as the target audience, be initiated using professional media sources designed to inculcate a feeling for, and love of, the land in those who, tomorrow, are going to be its managers.
16. There is clearly a greater need for integration of effort between the various agencies concerned in one way or another with conservation-related issues.
17. The author would like to see the establishment of a center or clearing house in Lebanon for information dealing with land use.

Lack of such coordination leads to wastage of manpower and financial resources and reduces the possibility of progress.

18. For educational institutions, such as A.U.B. and especially its Faculty of Agricultural and Food Sciences, the deficiencies in expertise in both personnel and courses in the area of range and wildlife management, soil and water conservation and environmental pollution, should be rectified.
19. In view of the similarity of the environment of the countries of the Arab World and those bordering the Mediterranean with common land-use problems, it is recommended that such problems be tackled by regional cooperation – seminars, publications, sharing of technical expertise, etc.
20. Those people involved in soil and water conservation should coordinate their efforts with other environmental groups whose common aim is a better, safer, healthier, more productive and more aesthetic environment for all.

Researchers

1. Establish the inherent susceptibility of the soils of Lebanon to erode i.e. the erodability factor of the Universal Soil Loss Equation. Such information could be presented on a map for the different soil types in Lebanon and thus highlight those areas where extra care in management is needed.
2. Rainfall maps could be interpreted to give values for momentum and kinetic energy which reflect the erosive power of rain. Such erosivity maps could pinpoint those areas in Lebanon where the hazards of erosion are severe. It should be borne in mind that the actual amount of soil loss is a function of the erosive power of either water or wind and the inherent resistance of the soil to erode.
3. Any research program in the area of soil and water conservation should be of a reconnaissance and an applied nature.
4. Integrate efforts and share ideas with fellow scientists in other countries of the region.

Farmers

1. Avoid cultivating land that is inherently susceptible to erosion i.e. steep slopes in areas of heavy rains. Such areas should be devoted to controlled grazing or forestry. While outside involvement by the Government may be necessary to offset financial losses in the short-term, this approach is the only viable solution for such land. In this connection, it is interesting to record the success of the World Food Program's "food for work" approach in Turkey (Ceres, 1981) in which supplemental feedstuffs were provided in order to induce farmers to allow native pastures to regenerate.
2. Where soil is eroded from the farmer's field along with runoff water, it is important for the farmer to realize that some of his fertilizer is also being washed away – thus reducing his net return from his enterprise. This can be minimized by conservation measures and proper timing of fertilizer application.
3. Crop residues or mulches should be left on the soil surface overwinter in order to reduce the damaging effect of winter rains. Letting land lie fallow promotes erosion and should be avoided despite the possible benefits from improved soil moisture.
4. Crop rotations should be practiced using legumes. This has been shown to improve soil structure and soil-water relations and thus reduce erosion. In view of the importance of organic matter in soil structure, practices which promote its buildup in the soil should be encouraged i.e. incorporation of residues, farm manures and organic industrial and municipal wastes.
5. Minimum or reduced tillage, combined with chemical weed control has been shown to greatly reduce erosion while still maintaining crop yields elsewhere. There is little, if any, reason why it could not be used widely in Lebanon, an attractive feature being the saving in energy costs.
6. The practice of deep plowing, common in Lebanon, is of doubtful value; in most cases, it is likely to increase soil erosion and reduce crop yields.
7. In moderate to steep slopes, the actual length of the slope should be reduced as much as possible to reduce erosion i.e. by terracing.
8. Adopt multiple cropping systems which give the soil maximum protection for most of the year thereby reducing the possibility of erosion.

9. Plant trees on waste land and on borders of fields. This would protect soil and plants, reduce moisture loss, serve as fencing, encourage bird and wildlife, provide shade and a more aesthetic environment, and ultimately provide wood for fuel and other purposes.
10. Rangelands should be rotationally grazed. This would lead to regeneration of better and more productive grass species and increase output.

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