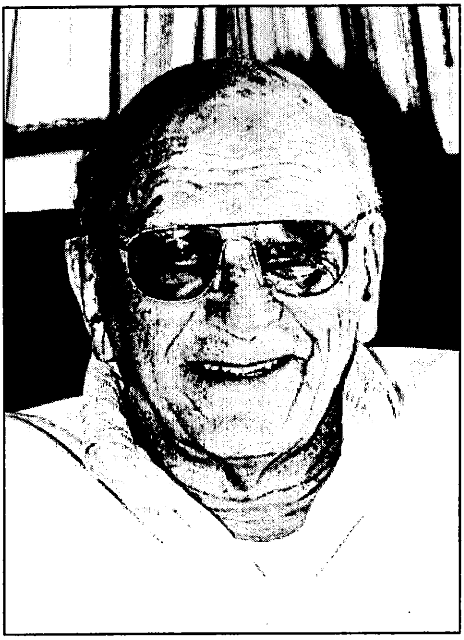

SOIL CARE ATTITUDES AND STRATEGIES OF LAND USE THROUGH HUMAN HISTORY

Dan H. Yaalon

The title of this article was the theme of the 1998 Symposium 45 which I organized, on behalf of the Committee on the History, Philosophy and Sociology of Soil Science, during the 16th World Congress of Soil Science in Montpellier, France. Over 20 oral and poster communications were presented and a volume of selected papers, including some supplemental ones, is now in press. Issues of soil erosion problems and of specific needs for soil conservation were in the past frequent topics of discussion at various soil meetings. Historical aspects of soil care attitudes were not considered previously. The purpose this time was to present a much broader view on attitudes to soil care and land use, in order to attract also non-soil scientists, and to present a review of the strategies used within the historical context of man's use of the soil.

The aim of this essay is to show that soils – the very slowly renewable and extremely variable bodies of nature – provide manifold important functions of relevance to mankind. Examples of both protective and negligent soil care and land use are evident in the cultural history of mankind and are part of our heritage. They need to be studied and understood for the sake of our future. George Sarton's saying "the present without its past is insipid and meaningless; the past without the present is obscure" is an appropriate motto for this.

Soils Defined : Their relevance to mankind

The scientific study of soils or *pedology* defines and views soils to be dynamic natural bodies (*pedons*) comprising the uppermost layer of the earth, exhibiting distict organization of the mineral and organic components, including water and air, which formed in response to atmospheric and biospheric forces acting on various parent materials under diverse topographic conditions over a period of time (Yaalon and

Arnold, 2000). This explains well the variable nature, properties and characteristics of soil bodies (pedons). The scientific notions and paradigms of the soil system were developed over the last 150 years following the pioneering contributions of V.V. Dokuchaev and N.M. Sibirtzev in Russia and E.W. Hilgard in America. Building on these foundations, Hans Jenny by 1941 developed an influential quantitative system analysis and Roy Simonson in 1959 a generalized approach to soil processes which became the leading paradigms of studies in soil genesis and pedology.

When considering the major functions and relevance of soils to mankind, their role as *life support system*, biomass producer and transformer, deserves prime mention. Soils support life. They serve as habitat for both macro- and microbiota. This function goes back to the origin of life several billions of years ago and for mankind to the beginning of arable agriculture some ten thousand years ago.

Soils supply moisture and nutrients for the vegetation, provide physical support for its roots and regulate the surface temperature regimes. Modern strategies of soil fertility and soil management have resulted in spectacular achievements in the ability to feed and to provide food security for the ever growing human population. Approximately 30% of the land surface is required for this role, significantly transforming the nature of the soils used.

More spatially limited though equally significant functions and roles of soils to society are to act as foundations for housing, roads and engineering structures, and to provide raw materials for these constructions, including clays for ceramic wares which were so important in our cultural history.

Globally, soils function serve as regulators of local, regional and continental hydrological regimes, and as reactors, filters and buffer of geochemical fluxes of bioelements and pollutants. They achieve this through their ability to dissolve, absorb, precipitate and selectively release elements. It is not surprising that in the current efforts to understand the mechanism and nature of environmental and global climate changes (IGBP projects, desertification), soils and their interactions with other systems play an important role.

Their relevance to related sciences includes the understanding of the co-evolution of soils and landscapes in geomorphology, the ability to date soils in reconstructing ancient environments in paleogeography, paleoclimatology and archaeology. In its role as a habitat for biota it has affected bio-evolution.

In the current context their relevance to societal and cultural aspects, as archives and heritage in connection with archaeology and history of civilizations will be dealt with in the following.

Soils and civilization

Beginning with the origin of cultivation agriculture some ten thousand years ago and its spread from the Near East towards Europe (Fig. 1), and subsequently also to other ancient centres of agricultural

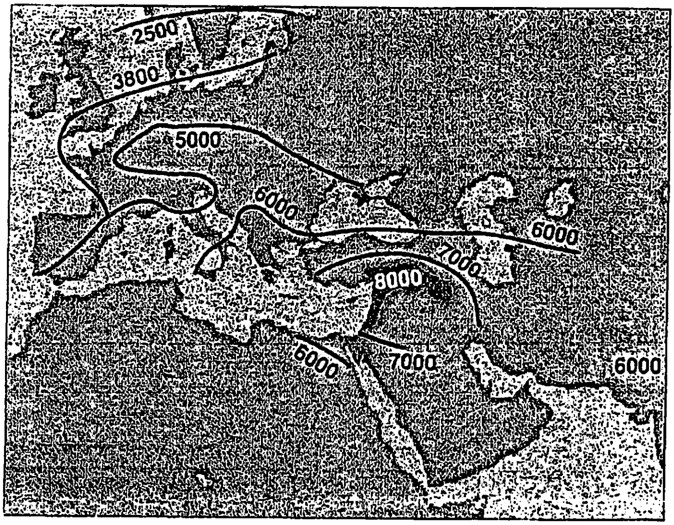

Fig. 1 Spread of agriculture in the Old World during Holocene in years Before Present

activity, humans have transformed continuously larger areas of the earth for their own use. Civilizations have evolved, grown, matured and collapsed. Some were destroyed by conquest, others by disease or some others by complex causes apparently without outside interference. The interactions of soils with the rise and fall of civilizations are intricate and have been dealt with by several authors (Whitney, 1925; Hyams, 1952; Dale and Carter, 1974). Many authors have dealt with the destructive effects of soil erosion in human history (Jacks and Whyte, 1939; Lowdermilk, 1953; Hallsworth, 1987). Only a few also included achievements of protective soil care and good soil management (Hillel, 1991; Johnson and Lewis, 1994). There is no doubt that the variable strategies used for soil care and land use which have affected the face of the earth (Thomas, 1956) have also influenced the history of mankind.

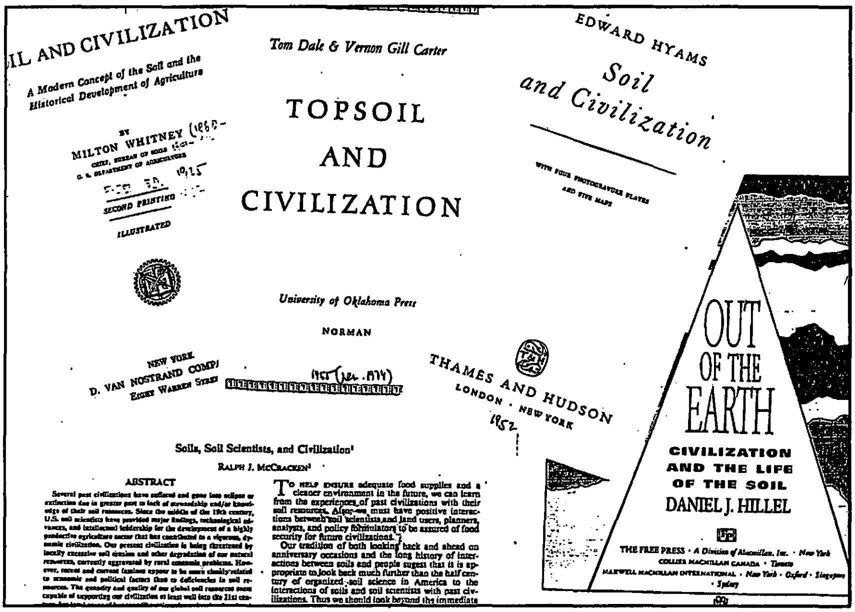

Fig. 2 Cover pages of some books with the Soil and Civilization title

Currently, climatic change has been evoked as a possible cause for the collapse of some past civilizations, accompanied by aridification and the concomitant decreasing fertility and soil salinization, e.g., during the third millennium B.C.E. in the Old World. Disputed by other researchers (cf. articles in Dalfes, Kukla and Weiss, 1997), the issue remains unresolved. For other collapsed civilizations (Harapan, Mesoamerican, etc.) there is also no definite evidence that climatic change and attendant erosion or soil exhaustion were the major causes for the collapse. They were, no doubt, an important contributing factor.

Societal and economic stability is a major factor in the continuous growth and life of a cultural entity. Political and social upheavals, resulting from whatever causes, are detrimental to sustainability. There are numerous examples of this for all climatic regions, especially for the aridic and mountain zones, where the naturally adverse marginal conditions motivated humans to develop specially adapted soil care strategies, like terracing and water harvesting (Reifenberg, 1955; Evenari, Shanan and Tadmor, 1971; Hadas, in preparation; McNeill, 1992; and several articles in Yaalon, 2000).

Strategies of soil care through human history

At this stage it is appropriate to list and review briefly the most common ecologically sound soil conservation or soil care strategies for arable soils. They include: cultivation for soil loosening and weeding – this original soil care methodology became now, because of modern heavy machinery, often harmful to the stucture of the topsoil so that limited tillage is being propagated instead; crop rotation - an underestimated simple strategy, often resulting in soil exhaustion if not practiced; terracing – an ancient labour intensive good soil practice suitable also for marginal soils; manuring, marling and liming - very valuable old practices, now frequently replaced by chemical fertilizer; water harvesting, irrigation, bunding – an ancient methodology, drastically changed by modern technology; ditch and tile drainage – needed to regulate high water table and to prevent soil salinization; and several others like contour cultivation, occasional deep plowing, mulching, stone removal, land levelling, fencing or shelterbelts.

Soil care in the context used here is broader than the more common term 'soil conservation' and more akin to the German 'Bodenschutz' ('soil protection'). *Soil care* has been defined as "selecting and implementing a system of soil use and land management that will improve and maintain its usefulness for any selected purpose" (Yaalon, 1997). That means not only for agricultural productivity but equally when soils are chosen for any other purpose or services, e.g. forestry, nature reserves, road building, sports grounds, or tundra, desert and wilderness soil-ecosystems. All land use requires appropriate care of their unique soils and landscapes when selected for a certain use. Not-only do non-arable soil areas exceed in extent those used for agriculture (Table 1) but they must be equally well managed in a sustainable mode and protected for improved quality of life for future generations. This, in addition to well cared arable land and pastures to feed the ever growing population, is the overall and ultimate goal of viable soil care and land use.

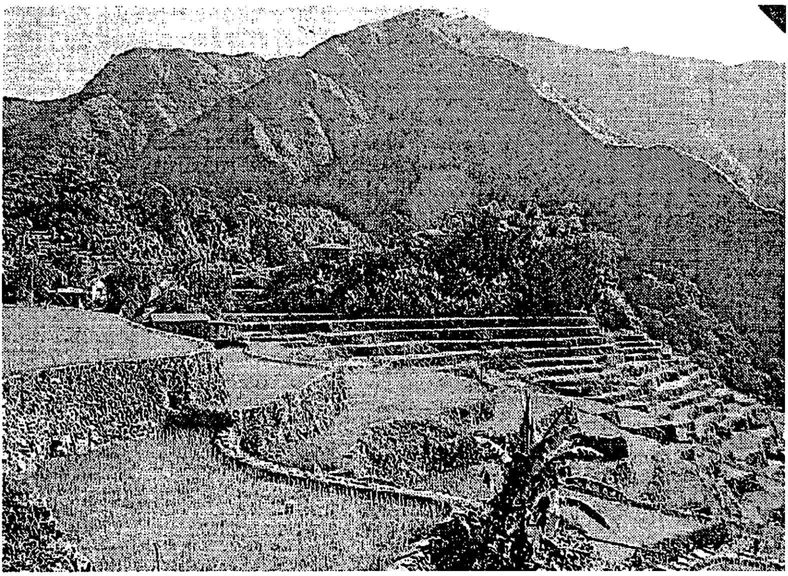

Fig. 3 Ancient terraces in the Near East

Several good soil care precepts are already enumerated in the ancient Hebrew bible and scriptures, such as requiring a fallow seventh year (sabbatical) when fields were not to be cultivated, maintaining crop diversity, redistributing land in the jubilee (50 th) year and similar demands. These ecologically sound prescriptions are a precursor of modern requirements of rotation and soil care (Borowski, 1987; Huttermann, 2000). The advantages of weeding and manuring for better productivity and yields was recognized even before this (Wilkinson, 2000), but historical and archaeological data on this are scarce except for China.

The evidence for ancient use of terracing on slopes, water harvesting and wadi irrigation, especially in the Old World, are more numerous (articles by Sandor, Sharma, and Brunner in Yaalon, 2000) and indicate that man was not averse to extending his habitation and soil care into essentially marginal regions, what we would today call difficult conditions and low quality soils. The ability to adapt to changing or frequently adverse soil and land conditions is a remarkable feature of human and social development.

Combating soil degradation

Inevitably, the ancient and current degradation of the limited soil resources attracted more attention than mankinds spectacular gradual increase in soil fertility and productivity. Though overshadowed by the widespread soil erosion and degradation of many Old World, Mediterranean and Maghreb (north African) landcapes, mainly a result of *deforestation and overgrazing*, ancient Greek, Roman and Muslim farmers also contributed their share of wisdom to good soil husbandry (Winiwarter, 1999; Bech, 1999; Butzer, 1994). In central and western Europe uncontrolled deforestation was the major cause of accelerated erosion in the past (Boardman and Bell, 2000). Liming, marling or plagging (Blume, 2000) and later ditch and tile drainage enabled better soil tillage conditions and yields. Colonial expansion and settlement resulted in major deforestation and severe soil degradation in the Americas, Australia and Africa, in time giving rise in the 20th century to soil conservation movements and government legislation about it (McDonald, 1941: Held, 1992; Hudson, 1985). Progress has been uneven. Highly successful in America, it was essentially ineffective in Africa and most developing countries. European Union and World Soil Charters by FAO were formulated without much impact.

The industrial age brought with it new agricultural machines, chemical fertilizer, pesticides and herbicides which through intensive research considerably effected better soil care and greatly increased soil productivity. However, some of these chemicals also had disastrous effects outside the arable farming domains, resulting in widespread pollution and the current ecological crisis. It sprouted an increased awareness of the holistic approach to nature conservation and viable soil care. The formulation of an internationally secured Soil Convention on Sustainable Use of Soils is now under discussion (Tutzing Project, 1998).

	Mil km^2	%
arable*	14	11
pastures	33	24
forests	37	27
open spaces**	50	36
built up	3	< 3

* Thereof 15 % irrigated
* Bare rocks, regs, dunes, gravel fans, badlands, tundra, saltflats.

Table 1. World land areas and soil use. Total area 137 million km^2
(Source : World Resources Institute and FAO)

World and continental statistics show that arable land covers some 12% of the land surface (Table 1). This is a relatively small percentage of the earth's surface. Soil care efficiency and yield productivity vary enormously among various countries. In most developing countries soil productivity and yields is only a fraction of what it is in the industrialized part of the world, leaving ample room for improvement in the future.

Uncontrolled deforestation in the tropics of Amazonia and Indonesia or accelerated erosion and soil degradation in countries suffering political destabilization (Haiti, Somalia, Ethiopia) are modern disasters. However, many general pronouncements of vast soil losses and acute threats to soil resources or food security are often unreliable or exaggerated, because of poor data on the true extent and nature of soil degradation (Oldeman, 1997). Better data are needed.

Degradation type	Light	Moderate	Strong and extreme	Total	(%)
	In millions of hectares (10^6 ha)				
a) ARID and SEMIARID REGIONS					
Water erosion	175	208	84	467	45 %
Wind erosion	197	215	20	432	42 %
Chemical degradation[2]	197	31	25	101	10 %
Physical degradation[3]	11	15	9	35	3 %
Total for a)	427	469	138	1035	100 %
b) TEMPERATE and TROPICAL SOIL REGIONS					
Water erosion	168	319	140	627	67 %
Wind erosion	72	39	6	117	13 %
Chemical degradation[2]	49	72	18	138	15 %
Physical degradation[3]	33	12	3	48	5 %
Total for b)	322	442	167	930	100 %
Total for (a+b)	749	911	305	1965	
In percent	38 %	46 %	16 %	100 %	

[1] The empirical expert evaluation based on GLASOD methodology is probably truthful to within 20 % of the estimates.
[2] Chemical soil degradation includes: salinization, nutrient losses and chemical pollution.
[3] Physical soil degradation includes: compaction, waterlogging and subsidence of organic soils.

Table 2. Extent of estimated human-induced degradation for the world according to type and degree of degradation, in million hectares (from Oldeman et al.,1997)

Globally, nearly 20 million km^2 are considered to be degraded through the impact of human activity (Table 2). This represents over 15% of the vegetated land surface (Oldeman, van Engelen and Pulles, 1991), from light - mostly reversible, to severe and extreme degradation -

essentially non-reversible. The major causes of soil degradation are water and wind erosion resulting from deforestation, overgrazing and technological mismanagement (Table 3). Nearly half of the original natural forests have been transformed to arable land or pastures. Reforestation is only now becoming active.

On a historical scale one can broadly identify several major pulses of this deforestation and degradation (Dregne, 1981; McNeill, submitted), not necessarily coincident in time in the different impacted regions: (a) during the prehistoric and early historic stages with the original spread of cultivation, generally after vegetation destruction and deforestation frequently using fire for this purpose as in examples in the Old World and China; (b) the next erosional pulse includes the life and fall of ancient agrarian civilizations cum mediaeval deforestation for timber, causing widespread soil erosion and alluviation downslope, while concomitantly various indigenous cultures developed innovative protective measures and sustainability; and next (c) the modern colonial expansion and technological pulse of the last 400 to 200 years due to vastly increased

	Africa	Europe	Asia	Austral-asia	N + C America	S America	World	
	In million of hectares (10^6 ha)							(%)
Deforestation	67	84	298	12	18	100	579	29 %
Overgrazing	243	50	197	83	38	68	679	35 %
Exhaustion[1]	63	1	46	-	11	12	133	7 %
Mismanaged technology	121	64	204	8	91	64	552	28 %
Construction	+	21	1	+	+	+	22	> 1 %
Total	494	220	746	13	158	244	1965[2]	

[1] Includes overexploitation

[2] This represents 15 % of total land surface, including light (reversible) to strong and severe (mostly irreversible) soil degradation without specific regard to the timing of its initiation.

Table 3. Inferred extent of major causative factors of soil degradation worldwide and by continents, in million hectares
(Source: GLASOD methodology estimates, Oldeman et al., 1991)

populations and spread into new territories. The modern technological impact continues to cause great damage to soil resources even though preventive and remedial methods are by now well known.

Inevitably, periodic famines occurred, when harvests failed because of inclement weather conditions. Famines were especially disastrous in the densely populated regions of India and China where millions of people often died as a result. These were overcome only in the last few decades, partly because of improved long distance transport of stored food from overseas. But it also is due to improved local crop yields, the result of improved varieties, chemical ferilizers, herbicides and pesticides. These current strategies for good soil care all resulted from intensive modern soil and crop research. Mankind has indeed been a soil fertility maker on a large scale, enabling better food security for the ever growing population, provided good soil care and land use husbandry is duly promoted everywhere. What about prospects for the future?

Prospects for the future

Available data and reviews call for a cautious optimism in food security for the future population, using the currently available soil resources. This requires a more holistic approach and planning, in both the local and regional or continental context, duly preserving forests and open spaces for general needs and better quality of life. Local 'bottom-up' initiatives are essential. Problems can no doubt arise in marginal areas, exemplified by semiarid regions where interannual variability in climatic parameters is especially large (Mainguet, 1998).

A shining example is that of semiarid Israel (population density now exceeding 350 per km^2) where high motivation of an educated growing population achieved spectacular results in developing high yielding agriculture, combating desertification, initiating reforestation projects and expanding nature reserves without disastrous effects to the geo-ecology and environment (Schechter, 1980; Givati, 1985). On the other hand many development projects in aridic regions promoted by international organizations essentially failed, partly because of insufficient local motivation and participitation. When in the Zagros mountains footslope region (population density 30 per kin^2) the traditional low-input agrisystem was compared to a high-input technological system for sustainability, the high-input agrisystem accomplished fast changes but resulted in soil degradation. It was concluded that for this kind of semiarid area high input was not recommended (Farshad and Zinck, 1995). Presumably there was insufficient local motivation and societal adaptation to modern high-input technology. This is a frequent conclusion of failed development projects (Blaikie, 1985).

Though vast areas of untouched open spaces in deserts and parts of tropical forests still remain as wilderness, the late 20th century and beyond is a human-dominated ecosystem (affecting about two thirds of the land surface) with a profound influence on the nature of soils and landscapes. Man has become the major geomorphic agent in transforming and transferring surficial materials on the face of the earth. Its multi-variable but limited soil resources are being continuously impacted and altered on a vast scale. We must learn lessons of the past and adopt an attitude for better soil care to attain *geo-ecological sustainability* worldwide.

Conclusions

Summarizing this overview with regard to past and current attitudes to soil resources, we can state that:

1. Soils are a precious and a very slowly renewable natural resource of manifold use and service to mankind.

2. Successful and negligent soil use and land management throughout history was and is equally common.

3. Protective and preventive soil care is needed for sustainable land use. Societal and economic stability is a major prerequisite.

4. Extensive soil degradation and loss of productivity may have wideranging social and cultural impacts.

5. Appropriate and effective soil care methodology needs to be adopted for each specific soil geo-ecosystem.

6. Many modern and ancient methods and strategies of soil care are known and are equally useful. Local participation and regional support are needed for successful execution.

7. More detailed and integrated soil and environmental history research needs to be promoted.

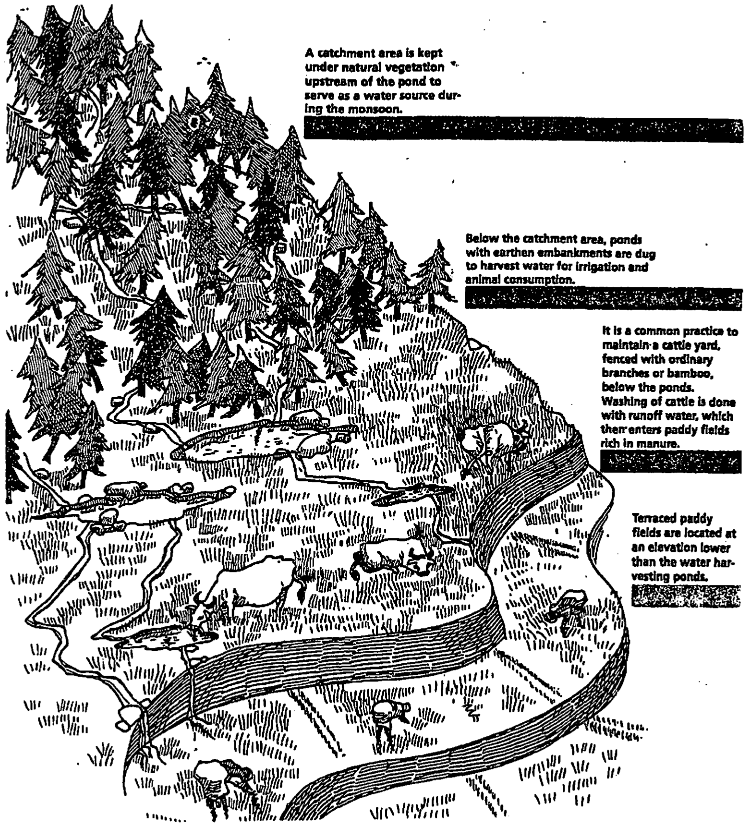

Fig. 4. The Zabo water harvesting and terracing system in nort-eastern India (after Agrawal, A. and Narrain, S., 1997, Dying Wisdom, Centre for Science and Environment, New Delhi.)