PART I

FOR SOIL THOU ART

We know more about the movement of celestial bodies than about the soil underfoot.

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PROLOGUE

ALL TERRESTRIAL LIFE ultimately depends on soil and water. So commonplace and seemingly abundant are these elements that we tend to treat them contemptuously. The very manner in which we use such terms as "dirty," "soiled," "muddled," and "watered down" betrays our disdain. But, in denigrating and degrading these precious resources, we do ourselves and our descendants great—and perhaps irreparable—harm, as shown by the disastrous failures of past civilizations.

Before I began my research, I had held the rather prevalent idea that human abuse of the environment is a new phenomenon, mostly a consequence of the recent population explosion and of our expansive modern technological and materialistic economy. Ancient societies, I presumed, were more prudent than ours in the way they treated their resources. For the most part, that has turned out to be a romantic fiction. My research has led me to the conclusion that manipulation and modification of the environment was a characteristic of many societies from their very inception. Long before the advent of earth-moving machines and toxic chemicals, even before the advent of agriculture, humans

began to affect their environment in far-reaching ways that destabilized natural ecosystems.

In many of the older countries, where human exploitation of the land began early in history, we find shocking examples of once-thriving regions reduced to desolation by man-induced soil degradation. Some of these civilizations succeeded all too well at first, only to set the stage for their own eventual demise. Consider, for example, the southern part of Mesopotamia ("the land between the rivers") which, as every schoolchild knows, was a great "cradle of civilization." We need only fly over this ancient country, now part of Iraq, to observe wide stretches of barren, salt-encrusted terrain, crisscrossed with remnants of ancient irrigation canals. Long ago, these were fruitful fields and orchards, tended by enterprising irrigators whose very success inadvertently doomed their own land.

The poor condition of the "Fertile Crescent" today is due not simply to changing climate or to the devastations caused by repeated wars, though both of these may well have had important effects. It is due in large part to the prolonged exploitation of this fragile environment by generations of forest cutters and burners, grazers, cultivators, and irrigators, all diligent and well intentioned but destructive nonetheless. The once-prosperous cities of Mesopotamia are now *tells*, mute time capsules in which the material remnants of a civilization that lived and died there are entombed. Similarly ill-fated was the ancient civilization of the Indus Valley in present-day Pakistan.

A haunting example of soil abuse on a large scale can be seen in the Mediterranean region, which has borne the brunt of human activity more intensively and for a longer period than any other region on earth. Visit the hills of Israel, Lebanon, Greece, Cyprus, Crete, Italy, Sicily, Tunisia, and eastern Spain. There, rainfed farming and grazing were practiced for many centuries on sloping terrain, without effective soil conservation. The land had been denuded of its natural vegetative cover, and the original mantle of fertile soil, perhaps one meter deep, was raked off by the rains and swept down the valleys toward the sea. That may have been the reason why the Phoenicians, Greeks,

Carthagenians, and Romans, each in turn, were compelled to venture away from their own country and to establish far-flung colonies in pursuit of new productive land. The end came for each of these empires when it had become so dependent on faraway and unstable sources of supply that it could no longer maintain central control.

The inability to ensure a dependable supply of water has also been a frequent cause of failure. A poignant example is the sad fate of Fatehpur Sikri, the magnificent capital built in northern India in the late sixteenth century by the Moghul emperor, Akbar the Great. Less than two decades after its completion, notwithstanding the splendor of its architecture, Fatehpur Sikri was abandoned entirely, for no other reason than the simple lack of water. Still more significant were the chain-well systems developed in ancient Persia. Some of these have remained in operation for several millennia, while abandoned remnants of others stand as mute testimony to the dangers of groundwater mismanagement.

There were, on the other hand, a few societies that did better than others. Some ingenious and diligent societies developed technologies that enabled them to thrive in difficult circumstances for many centuries. Judicious management of soil and water is exemplified in some of the arid regions of the Near East and the American Southwest. Equally impressive is the evidence regarding the long-lasting wetlands-based societies of Meso-America and South America. Remarkably productive wetland management systems have survived intact in China and other parts of Southeast Asia. In contrast with the historic failures of Mesopotamia and the Indus Valley, the irrigation-based civilization of Egypt sustained itself for more than five millennia—though it is now beset with problems of unprecedented severity.

Every one of the insidious man-induced scourges that played so crucial a role in the decline of past civilizations has its mirror image in our contemporary world. But it seems that the mirror is warped, and the problems it reflects are magnified and made monstrously grotesque. Human treatment of the environment has grown worse, and in our generation it has brought us to a

point of crisis. Salinization, erosion, denudation of watersheds, silting of valleys and estuaries, degradation of arid lands, depletion and pollution of water resources, abuse of wetlands, and excessive population pressure—all are now occurring more intensively and on an ever-larger scale. Added to the old problems are entirely new ones, including pesticide and fertilizer residues, domestic and industrial wastes, the poisoning of groundwater, air pollution and acid rain, the mass extinction of species and, finally, the threat of global climate change.

Among the most egregious examples of latter-day abuse is the drying of the Aral Sea in the USSR, once the world's fourth largest fresh-water lake, now made briny and charged with poisonous chemical residues. An even greater disaster is the progressive decimation of the tropical rain forests and the resulting wholesale eradication of entire ecosystems. Intensified runoff, accelerated erosion, and flooding of lowlands are now widespread, and in places—for example, in Bangladesh—the results are disastrous. The degradation of vegetation and land in arid regions, a process called desertification, is occurring on a continental scale in Africa and elsewhere. Irrigated lands in such disparate countries as Australia, Pakistan, India, USSR, and the United States are losing their initially bountiful fertility and in district after district are being withdrawn from production.

Yet there are hopeful developments, too. We know much more about the natural and man-induced processes at work; we understand and can anticipate some of their consequences. Degradation and pollution are not inevitable. They can be controlled. We can avoid the major abuses and devise better modes of environmental management. Land and water husbandry can be improved and sustained.

As the reader may have already noticed, this book is not a strictly dispassionate exposition. Its topic is of intense personal interest to me. That interest has been lifelong. Born in a man-made oasis in the semi-desert of southern California, I was taken at an early age to Palestine, then in the first stages of reclamation from centuries of desolation. I spent part of my childhood in a pioneering settlement in the Jezreel Valley where, in Biblical

times, Gideon drove off the hordes of desert nomads who periodically descended like locusts upon the laboriously cultivated fields of settled farmers.

Here, the ancient struggle between the wilderness and the sown, between wandering herders and sedentary cultivators, between the descendants of Abel and Cain, has been waged since civilization began. And it was here at the thin edge of life that I was first captivated by the land and its contrasts, indeed by the whole environmental symphony with its counterpoints of sky and earth, soil and water, plants and animals, wilderness and agriculture. I remember myself as a child of nine, standing barefoot in an irrigated furrow, mired in the squishy ooze, gazing at the gurgling waters slaking the harsh dry clods, marveling at the exuberant growth of tender saplings in the tiny watered grove that rose up so defiantly against the vast expanse of the surrounding arid plain.

That early fascination with soil and water has grown over the decades to become both a vocation and an avocation, a professional career and a labor of love. After earning academic degrees in agronomy and the earth sciences in America, and working for the U.S. Department of Agriculture, I returned to Israel shortly after its birth as a state. There I took part in a systematic survey of the country's soil and water resources, and in efforts to restore productivity to the erosion-ravaged land.

Later, while helping to establish the first settlements in the highlands of the Negev Desert, I had the unique opportunity to witness the compression of four millennia in the history of land and water management into a mere score of years. I lived for a while with the Bedouin, who at that time were wandering bands eking out an austere existence by grazing emaciated goats and camels on the sparse shrubs of the rock-strewn slopes. Their mode of life resembled that of the Biblical Patriarchs, and of the 12 tribes of desperate desert nomads who were led by Moses and inspired by the vision of a Promised Land with flowing brooks and lush meadows. To me, developing the Negev's agriculture seemed like a re-enactment of the process by which the ancient Israelites metamorphosed from roaming shepherds into

permanent planters, and learned the ways of soil and water-husbandry.[1]

One of my most inspiring early experiences was the chance to associate with a man of great vision who combined idealism with realism in an unique way. On a chance visit to our little village in the desert, David Ben Gurion, Israel's Founding Father and first Prime Minister, made a sudden decision—astonishing for a political leader at the peak of his power—to resign from the government and come to join and work with us at our arduous task of land reclamation.[2] Ben Gurion lived out his life in that desert village, which we called Sdeh-Boker ("Herdsman's Field"), and is buried there. And it was at Sdeh-Boker that he enunciated his credo: "The energy contained in nature—in the earth and its waters, in the atom, in sunshine—will not avail us if we fail to activate the most precious vital energy: the moral-spiritual energy inherent in man; in the inner recesses of his being; in his mysterious, uncompromising, unfathomable, and divinely inspired soul."

A friendship that formed in the mid-1950s between Ben Gurion and U Nu, then Prime Minister of Burma, led to an agreement between the two countries to develop mechanized crop production in the Burmese upland regions.[3] And so it was, following my experience in the Negev, that I was asked to undertake a very different kind of mission to the tropical rain forests and drenched river valleys of Southeast Asia. The task in Burma and later in Thailand was to help initiate permanent cultivation of upland soils in place of the "primitive" local practice of "shifting cultivation." My experience there and later in other parts of the Third World led me to realize the fallacy of our initial, simplistic assumption that, given enough machinery, fuel, chemicals, and know-how from the outside, underdeveloped lands could be reclaimed straightaway and cultivated without any serious environmental, social, and economic problems.

Returning to Israel, I served as head of the Soil Technology Division of the state's Agricultural Research Organization, and later as head of the Soil and Water Sciences Department at Hebrew University. During the 1960s and early 1970s, I took

part in the intensive effort to improve the efficiency of water-use that resulted in doubling crop yields while reducing average crop water requirements by one-third—a singular achievement of the State of Israel.

In the course of my subsequent career with various national and international agencies, I have had occasion to observe and experience the management and mismanagement of land and water on every continent and in varied locations and circumstances, humid and arid, tropical and temperate, in developing as well as in developed countries. Among my tasks have been research, consulting, and managerial assignments[4] in such varied countries as Iran, India, Pakistan, the Philippines, Japan, and China in Asia; Cyprus, Italy, Belgium, France, and Holland in Europe; Nigeria, Egypt, the Sudan, Ethiopia, the Ivory Coast, and Mauritius in Africa; the continent of Australia; as well as Colombia, Mexico, and Canada in the Western Hemisphere. In addition, I have worked extensively in the United States on problems of soil and water management and the protection of the environment. I have also had occasion to conduct professional visits to the Soviet Union and the countries of Eastern Europe, as well as to several countries in sub-Saharan Africa and Latin America. Throughout these ventures, I have striven to gain a global perspective regarding the two major dilemmas besetting the world in our time: the widespread recurrence of famine affecting many nations, and the evident deterioration of the environment affecting all nations.

I believe that any rational control over the impact that human activity has on the environment must be based on a fundamental understanding of the processes at work. Obviously, we cannot protect what we do not understand. It is in the interest of promoting and disseminating such an understanding that I have undertaken this book. My treatment of the subject, however, is not meant to be encyclopedic, but illustrative. In selecting the aspects to highlight, as well as in setting the style, order, and tone of the exposition, I have had to make personal judgments. Being an environmental scientist, I have chosen to devote primary attention to the natural resources of land and water and to the

physical-biological processes (both natural and anthropogenic) governing them. At the same time, I am aware of the importance of social and economic factors that impel human societies to treat these resources as they do.

In writing this book, I have attempted to explain rather than advocate. However, I cannot and should not hide my point of view. I am a committed naturalist who nevertheless supports development, provided it is judicious and environmentally sound. I have tried to strike a balance between the lamenting or castigating tone now fashionable with some environmentalists, and the complacent view of those inveterate optimists who trust blindly that our problems will somehow be solved by a scientific or technological *deus ex machina.* I do not wish to preach an angry jeremiad of fire and brimstone, but to explore the lessons of our past and present relation to the earth from whence we came, and to which we must return—in spirit as well as in body.