Land Transformation in Agriculture
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CHAPTER 8
Land Transformation in Israel

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8.1 INTRODUCTION

The countries around the Mediterranean have experienced far-reaching changes in land quality and land use. The centres of very early, highly developed civilizations of the western world were here. Together with their great achievements they brought about intensive use of the land—sometimes excessive use.

The political changes that affected the area during a millennia of its history involved similar changes, for better or for worse, in husbanding of the land. Extensive areas of olive groves—famous since antiquity—fruit orchards and vineyards, many of them grown on carefully terraced slopes, indicate but some of the prominent achievements of mediterranean agriculture. By contrast, periods of decline, being sometimes periods of depopulation, brought about very adverse effects, in particular abandonment of cultivated land and disrepair of the terraces. In consequence there was erosion of the soil, and downwash into the valleys of the lowland plains; there was excessive sedimentation in these valleys, choking the river and wadi beds, and sometimes followed by formation of swamps owing to lack of drainage; and not infrequently malaria affected these swampy areas. This whole syndrome of land deterioration is illustrated in many mediterranean countries.

A classic case is Israel of the nineteenth century. Israel showed some significant achievements in agriculture and land development in antiquity, and the deterioration is easy to follow in detail. Two factors bring about particularly significant effects of processes of land transformation. One factor is the country's dense population and its high rate of urbanization. The population density, exclusive of the Beersheva district, the largest area of which comprises the Negev Desert, was 517 per square kilometre by the end of 1980, and 86.7% were classified as urban (90.4% of the Jewish population). Demands for transformation of non-urban land to urban land uses are therefore particularly pressing.

The second factor is the great geographical diversity of Israel. Its elements are plains and mountains, the latter a veritable mosaic of geomorphic units, upon which are superimposed two different climatic areas—the mediterranean climate in the north and the arid climate of the Negev Desert in the south. The Judean Desert on the east flank of the mountains and the Rift Valley of the Jordan owe their aridity to their topographical location in the rain-shadow of the mountains. This diversity intensifiies the effects of land transformation, especially if the changes occur near the border of aridity, being the transition from mediterranean to desert climate, an area particularly sensitive to change.

This diversity of landscape, the sensitivity to changes near the border of aridity, and especially the long and varied history of the land of Israel, acted upon by a variety of civilizations, and its extensive documentation, make Israel a particularly apt topic for a study in land transformation.

8.2 LAND TRANSFORMATION IN ANCIENT TIMES

Although evidence for land transformations in ancient times is often of a general nature only, it is sufficient to illustrate some major trends. There is evidence to show that the natural vegetation of the uplands of Israel, from Galilee in the north to beyond Hebron in the Judean hills in the south, were forests in the natural state (Gradmann, 1934, especially map 1; Zohary, 1955; 1970). They were covered by a mediterranean mixed forest. One of the major land transformations of Israel in antiquity was the removal of this upland forest, presumably to obtain building materials and fuel, possibly in part by setting fire to it for purposes of hunting, or even to clear the ground for settlement. One less 'legitimate' reason for deforestation was the need for materials for military purposes, especially siege machinery. Historical sources have it that the Roman command, when besieging Jerusalem in 70 AD, had to send troops to provide logs and wood for their siege works as far as 90 stadia (18 km) from the city, as all the area nearer to Jerusalem had already been deforested long ago.[1]

It is assumed (Reifenberg, 1955) that this deforestation of the uplands resulted in a standard series of consequences: erosion of much of the topsoil, which in most areas was of the terra rossa type, elsewhere rendzina; excessive sedimentation in the adjacent coastal plain, resulting in waterlogging in the valleys; local creation of swamps, which eventually became foci of malaria; which, becoming endemic, weakened the population and its capacity for work, and sometimes led to desertification of villages, and even to abandonment of cultivation of land. There were at certain times secondary factors fostering abandonment. The coastal plain of Israel was an inter-regional highway of traffic between Syria in the north and Egypt in the south-west. It was used by, amongst others, many armies and marauding bands which plundered and extracted tribute or forced labour. Nomadic tribes from the

deserts around Israel contributed their share to this development. They sent occasional or regular raiding parties (*ghazzus*) to obtain livestock and protection money—a kind of forerunner of modern mafias.[2]

As a result of all this the Romans had to apply drainage works to swamp areas of the intrinsically fertile coastal plain, at least on the southern Carmel coast (Nir, 1959) and at the Poleg valley south of Netanya. These drainage works fell subsequently into disrepair and considerable areas turned into swamps infested by malaria. This situation persisted into the nineteenth century.

However, long before this—apparently as early as the Second Temple period (the second half of the first millennium BC)—a vast project of improvement in land transformation was undertaken. This was a project rather improbable from the point of view of the twentieth century. Instead of reclaiming the plains land, which would have required drainage technology and conditions of security that apparently were not available to the population of those times, the rocky upland hillsides were transformed into agricultural land. Agriculture, therefore, centred on the uplands—much of it karstic, where soil was very shallow, if soil indeed had remained at all—instead of in the lowland plains where there were relatively deep soils. This land transformation involved a tremendous investment of manual labour to create agricultural terraces, which in certain areas covered more than 50% of the total land surface (Ron, 1966). The construction of terraces did benefit from a roughly horizontal stratification of the prevalent limestone rock. They were relatively narrow and accumulated a cover of terra rossa soil, on which traditionally olives and some fruit trees were grown, with cereals (mainly wheat) below them. The size and topography of the terraces excluded any mechanized agriculture, and do so even today in the limited areas where ancient terraces are still cultivated. A mule or donkey is the only means used for ploughing beyond manual labour.[3]

Obviously, to terrace the uplands of Israel, especially the Judean Mountains, would be impossible and unreasonable under present socio-economic conditions: the standard of living, and therefore the cost of labour, would prevent both their installation and their cultivation. The philosophy behind these large areas of agricultural terraces, in Israel, in countries around the Mediterranean at large, and in many countries of the Far East (Sorre and Sion, 1934, pp. 41–42 and 46–48; Spencer and Hale, 1961) is based on minimal cost and a nearly unlimited availability of manual labour—about the opposite of conditions obtaining in the late twentieth century, at least in developed countries. That in many countries terraces were the prevailing form of land use illustrates not only the basic socio-economic difference between the past and the present, but no less the well-known fact that before the industrial revolution there were but few alternatives to employment in agriculture.

The active period of this upland transformation into terraces and their full

cultivation seems to have continued up to about the Arab conquest (seventh century AD). Throughout these times and until the nineteenth century the uplands were the important region in Israel's agriculture, and therefore its rural settlement; the lowlands and their plains with their rich natural resources for agriculture ranked a poor second, or were barely cultivated. In the second millennium AD most of the terraces were gradually abandoned and deteriorated by disrepair. Today, only a few of these terraces are still cultivated, mainly by Arab villages marginal to the mainstream of modernization.

Coincident in time, but not in space, with the creative stage of land transformation in the uplands there occurred an extraordinary development in desert agriculture in the central Negev in the south. It was initiated apparently by the Nabateans in the first century BC and might have persisted up to the Arab conquest in the seventh century. Considering both the area to which it was applied and the agricultural technology employed, it was exceptional. Both 'Nabatean agriculture' and mediterranean terrace cultivation had in their days a wide regional distribution; but unlike upland terracing, Nabatean-type agriculture had a special intellectual quality, based on a detailed understanding of the mechanism of desert nature (Evenari *et al.*, 1971; Kedar, 1967; Amiran and Kedar, 1959; Yair, 1986).

The Nabatean introduction of agriculture into this fully arid environment was apparently subsidiary to their main activity, which was trading along caravan routes. On some of the slopes fruit trees were grown, apparently, and possibly vineyards. But more important, in order to utilize the rare and highly irregular rainfall, they installed their fields in the wadi beds, with proper channelling of the rainfall from the slopes to each individual field. The slopes were specially treated to channel the runoff, and apparently to facilitate washdown of soft soil elements as well, which would accumulate in the wadi bed as substratum for cultivation.

In view of the rarity and sparseness of rainfall, there was an extraordinarily large ratio between the drainage area on the slope and the individual field on the valley bottom to which it provided runoff water—between 17:1 and 30:1, with an average of about 20:1. Owing to the strong floods which sweep the major valleys, Nabatean agriculture was restricted mainly to secondary wadis. The Nabateans, furthermore, devised a special type of cistern, adopted to the conditions of the prevailing types of rock, which passed the incoming runoff water through a strainer compartment, reduced evaporation, and was fitted with stairs to draw the water at successively lower levels without stirring up the bottom deposit.

By all these means the Nabateans managed to live in a desert which today has an average annual rainfall of 80–90 mm.[4] With the cessation of their caravan trade, their agriculture and their towns[5] were abandoned and never revived (except today at an experimental farm at Avdat).

8.3 RECLAMATION AND REASSESSMENT OF THE LOWLANDS

The type of extensive agriculture characterized by the slope terraces of the uplands persisted with little improvement until the late nineteenth century. It was only then that the next decisive step in land transformation and improvement of land use was taken.

Not bound by tradition nor by resignation to the run-down state of the natural resource base of agriculture, the leaders of the Zionist settlers who returned to their ancestral homeland made an unbiased and modern reappraisal of the conditions of the land. They appreciated the agricultural potential of the soils of the coastal plain, provided they were properly drained, which in turn would permit the eradication of malaria.[6] They understood the need for irrigation under the climatic conditions of the inhabited northern part of Israel.[7] Its mediterranean-type climate had too unreliable a rainfall on which to base a stable agricultural society. Furthermore, the potential advantages of the warm summer in a climate that has exclusive winter rains could be utilized only under irrigation.

Consequently, projects of drainage and reclamation of the plains were initiated—a lengthy, difficult and costly process, as was gradual development of groundwater resources for irrigation. The latter development, which began in the 1880s, culminated in the 1950s and 1960s with the inauguration and eventually full operation of the National Water Carrier.

All this resulted in one of the most far-reaching revolutions in land transformation in Israel. The lowlands—fertile and productive regions in antiquity—which had more and more deteriorated over time, and which by the nineteenth century were a rundown and partly abandoned area, became again in the twentieth century the prime agricultural region in which the economic core areas of Israel developed. Drainage and land works reclaimed the coastal plain, including the Haifa Bay between Haifa and Acco (Acre), which had been swampy and highly malarious owing to the obstructed drainage of the Na'aman River. Also reclaimed were the inland basins—the large Yizre'el Basin (Plain of Esdraelon) and the adjacent basins of Harod and Beth Shan to the east, sections of the Middle Jordan Valley north of here towards Lake Kinneret (Lake Tiberias or the Sea of Galilee), and finally the large and potentially very fertile Hule Basin in the northern part of the Jordan Rift Valley.

The inland basins had a variety of soils with a considerable percentage of heavy alluvial soils, in part the remnants of the swamps. Cultivation here, therefore, was mixed, including field crops such as cereals, fodder crops and vegetables, and later (since the 1960s) cotton. In contrast the coastal plain has a narrow stretch of heavy alluvial soils in the east at the foot of the mountains, but most of it consisted of light sandy soils, partly the weathering product of former stretches of coastal dunes.

Table 8.1 Citrus production and exports

Planted areas (ha)	
1922	29 000
1930	106 500
1948/49	125 000
1961/62	360 000
1979/80	396 000
Production (t)	
1948/49	272 700
1961/62	532 500
1979/80	1 542 700
Exports ($ million)	
1949	18.0 (63%)
1960	48.2 (22.25%)
1970	94.1 (12.1%)
1980	233.6 (4.2%)

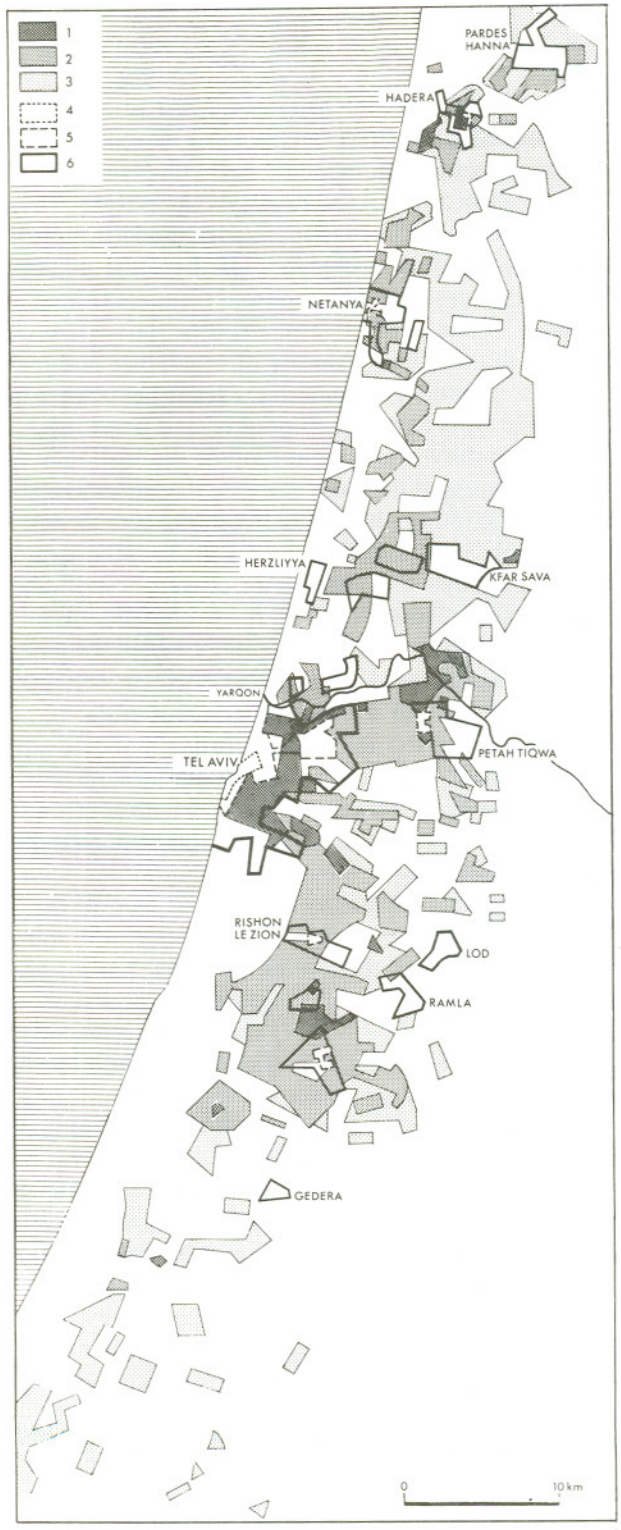
Sources: Statistical Abstract of Palestine 1937–38, and Statistical Abstract of Israel for relevant years.

These light sandy soils, which are rather permeable and poor in mineral content, had been considered a poor agricultural resource in the past. They were but barely used for agriculture, and much of them carried a secondary forest of spontaneous growth in which the oak (mainly *Quercus ithaburensis*) prevailed. The last sizeable remnants of this forest were cut down to fire Turkish railway engines in the First World War. The availability of irrigation put a premium on these light soils. They permitted a vast extension of citrus plantations, which by the turn of the century gave Israel's major export crop and which retain their primacy among agricultural exports to the present (Table 8.1). Irrigation was at first from local groundwater wells, and is today from the National Water Carrier. The modern development of water resources permitted the southward extension of citrus acreage and of other crops. Today, the Gaza area 52 km south of Tel Aviv is one secondary centre of citrus growing (see Figure 8.1).

Citrus is but one element in Israel's agriculture. As agricultural economics,

Figure 8.1 The development of areas of citrus orchards and built-up areas in Israel between 1922 and 1967. Information was obtained from the *Atlas of Israel* and survey maps, and the map was kindly drawn by Mr N. Z. Baer of the Department of Geography of the Hebrew University of Jerusalem

(1) Area of citrus orchards in 1922
(2) Area of citrus orchards in 1937
(3) Area of citrus orchards in 1967
(4) Urban built-up area in 1922
(5) Urban built-up area in 1937
(6) Urban built-up area in 1967


1
2
3
4
5
6
PARDES HANNA
HADERA
NETANYA
HERZLIYYA
KFAR SAVA
YARQON
TEL AVIV
PETAH TIQWA
RISHON LE ZION
LOD
RAMLA
GEDERA
0
10 km

genetics and agrotechnical research progressed, the variety of crops grown in Israel expanded considerably, both for the local market and for export.

The termination of the British mandate and independence for the State of Israel in 1948 put high stresses on the country's agriculture. The great wave of immigration in the early years of independence made it more than hard for the Israeli farmer to satisfy the demands of the local market. But by the mid-1950s the situation eased and agricultural planners turned their attention again on 'industrial' crops and on farm exports. Therefore, in addition to cereals for the local market, and a variety of vegetables and fruit, 'industrial' crops such as cotton, peanuts and sometimes sugar beets were now grown, as well as cattle (mainly dairy) and much poultry and pond fish.[8]

In the early years, before the inauguration of the National Water Carrier, farm practice had progressed from dry farming to partial irrigation with what was known as 'mixed farming', including livestock, cereals and fodder crops, vegetables and possibly fruit as well, all grown in the same farm unit. This was a kind of insurance against the vagaries of climate, especially the seasonal amount and distribution of rainfall.[9] With the availability of an expanded and reliable water supply from the National Water Carrier, agriculture started to specialize and focus on a rather limited range of crops, benefitting both from the advantage of specialization and the economy of scale.[10]

Much later, when after 1967 the Lower Jordan Valley south of the Beth Shan Basin again became accessible to the Israeli farmer, here too a radical land transformation occurred. This is an area with a distinctly arid climate, the result of its location in the rain-shadow of the uplands of Samaria and Judea a thousand metres and more below them.[11] For generations prior to 1967, this hot and sticky area was unavailable as agricultural land to the fellaheen and their simple agricultural technology (there were some very minor exceptions based on mediocre springs at the outlet of Wadi Far'a). Here the same regional advantages for out-of-season agriculture prevailed as the Israeli farmer had learned to use in the Negev; water was provided by systematic drilling on the fault borders of the Rift Valley, and an intensive agriculture has developed in the Jordan Valley since the late 1960s. It uses as a soil base the alluvial cover spread by the large and small valleys coming down from the uplands over the saline marls and underlying rocks of the rift bottom. In this respect the Jordan Valley has a definite advantage over the Negev, where sterile *hamadas* are the standard cover of the area and arable soil occurs in strictly limited locations. Incidentally, under essentially similar conditions, the Ghor project has been developed across the river in Jordan.

It is important to note that present-day Israeli farmers were not the first to engage in agriculture in this potentially fertile region. In antiquity, farmers used a sophisticated technology widely used throughout the Middle East; they installed kanats—underground tunnels for conducting water—in order to cultivate areas in the Phasaël region at the outlet of the Far'a Valley. These

fell into disrepair, and cultivation ceased here apparently more than a millennium ago (Cressey, 1958; Evenari *et al.*, 1971, pp. 172–178; Porat, 1970; Ilan, 1973; Troll, 1963).

The Lower Jordan Valley is thus another striking example illustrating that a certain region with a distinct agricultural potential was utilized in antiquity by farmers to whom kanat technology was available. It reverted to anecumene for well over a thousand years when backward farmers employing simple, 'traditional' methods of farming had neither the means nor the initiative to cultivate it. In recent years this same area—apparently even larger in size than in antiquity—forms a flourishing agricultural district thanks to research that has developed a technically advanced agriculture.

There is one specialized aspect of land transformation that deserves special mention—*fish ponds*. Apart from the insignificant amounts of sea fish landed by Arab fishermen at Jaffa and Acco, there was no supply of fresh fish in Israel. In the mid-1930s a few fish ponds were installed in the Kurdaneh swamps in the Haifa Bay using the saline water of the nearby springs. At the time carp of near-marketable size were imported from ponds in Yugoslavia and sold in Israel when they reached proper size. This was a profitable business, as carp for 'gefillte fish' commands a good market for the Jewish shabbat and holy-day table. The Kurdaneh enterprise, however, was an ephemeral project.

In the mid-1950s fish-ponding was revived, this time at first in the Beth Shan Basin. When the water resources of the basin were being developed, some large saline springs had to be reckoned with. Their water, as was that of the Kurdaneh springs mentioned above, was too saline to be used in agriculture. Part of it was mixed with good-quality water to an admissible level of salinity and was used for irrigation. The more saline water was used for fish ponds. In this way two sub-marginal resources were utilized. A few years later fish ponds were integrated into the agricultural layout of the Huleh Basin on completion of its drainage: surplus water was available here and used in the ponds.

Pond-fisheries soon appeared to be one of the most remunerative branches of Israeli agriculture, owing to the low input of labour. Fish ponds, therefore, appeared in most of the plain areas of northern Israel, as far south as the Hadera region of the coastal plain.[12] In the coastal plain, ponds were even installed on dune sand quite near to the beach. The sand was made impervious after a short time by lining the pond with chicken manure. Poultry manure, in fact, was a major element of feeding. Poultry farming and fish breeding, therefore, were often connected at the village (or at least at the regional) level. Fish breeding remained a preferred branch of agriculture for many years and receded only recently (Table 8.2). Unlike the early venture at Kurdaneh and its successor in the Beth Shan Basin, most fish ponds now use regular water from the National Water Carrier, augmented by rainwater. As

Table 8.2 Fish ponds

	Area (ha)	Volume of production (t)
1948/49	1 500	2 509
1969/70	5 400	12 000
1978/79	4 100	13 900

Source: *Statistical Abstract of Israel* for relevant years.

this involves high water losses by evaporation, the Water Commissioner is not in favour of expanding pond acreage, and actually attempts to restrict it.

The striking progress of lowland agriculture in various regions of Israel as treated above had negative repercussions on land use and the agricultural economy of the uplands. It has been mentioned that most of the upland terraces were gradually abandoned and deteriorated by disrepair throughout the second millennium AD. It is a telling expression of the state of deterioration of Israel prior to Zionist reclamation that, irrespective of this deterioration of upland areas, the uplands were still the most important agricultural region and the (economically speaking) 'leading' part of the country, if this term is applicable in the present context; and the region was definitely the most densely populated area until very late in the nineteenth century. All this is a striking measure of the decline and deterioration of the area over many centuries, which came to an end less than a hundred years ago.

The striking advances of lowland agriculture, and the standard of living they allow, today make upland farming on terraces a very poor second best. This applies not only to the resulting standard of living for the farmer, but also to the cost of the product, and therefore its ability to compete in the market. When labour was still relatively inexpensive, terrace agriculture was maintained in the Arab sector, and even slightly expanded beyond the nineteenth-century acreage. Similarly, a number of Jewish villages cultivated upland areas, mainly on terraced land, some of it improved and modernized. Today, when labour is nearly the most expensive element in agriculture, there is further regression of upland agriculture, the progressive element of which concentrates on specialized crops for which there is a regional advantage in the uplands, and to a large extent in the development of recreation as a regional resource, for which the uplands have a definite climatic advantage. These include rest houses, and even hotels, restaurants, picnic areas, recreational forests, swimming pools, sports grounds, and the supporting agricultural production. All this is in addition to generally small—but often highly specialized—industrial plants, which in many upland villages are today the most important branch in the village economy (particularly in kibbutsim).

To sum up, by the second quarter of the twentieth century the century-old pattern of land use in Israel had been radically transformed. The plains were again the country's principal agricultural area, in a modern agricultural technology and economy. The uplands, which for many centuries had been the important agricultural region and the important region of settlement, reverted to second rank in regional status, with the resort industry and an increasing residential land use by a commuter population assuming gradually more importance as the major regional resource base (see section 8.6).

8.4 PRIMARY RESOURCE BASES FOR AGRICULTURE (OTHER THAN SOIL)

The *mise-en-valeur* of land for agriculture in Israel until the 1950s had proceeded on a conventional pattern, expanding by a series of agro-technical improvements. The completion of the National Water Carrier in the 1960s, which led to both a much greater rentability and reliability of farming,[13] and therefore created considerable capital resources, permitted the natural resource base to be used in a new and unconventional way. This involved a number of phases, each one with special regional emphasis.

A sober appraisal of the possibilities created by the difference between the winter climates of the northern Negev (and better still the Arava section of the Rift Valley further to the south) and that of the European market, and to a lesser degree that of the populated north of Israel, brought about the *mise-en-valeur* of these areas which, until about 1950, had been considered entirely unsuited to agricultural use. Parts of the desert south of Israel with a fully arid climate were transformed into intensively cultivated agricultural land. The key to this development was the inter-regional differences in winter climates (Table 8.3). Even in mid-winter, the average daily maximum temperatures are high enough to permit the harvesting of vegetables and fruits, as well as flowers which were for a time part of the region's exports. The desert climate, which by its very nature has minimal and very infrequent rainfall,[14] therefore has minimal cloudiness as well. This even gives it an inter-regional advantage over the north of Israel, with its mediterranean climate and winter rains.

For this resource base for 'out-of-season' agriculture, suitable soils and water had to be identified, capital for basic investment provided and the marketing structure organized. By definition, neither water nor soil for agriculture are usually available in a desert; but here the special geographical conditions of the Arava as a section of the Rift Valley become a positive asset. Groundwater could be located by drilling at certain places on the fault borders of the rift; it could then be piped to the area to be cultivated. The soil component is available at rather special locations, different from the norm in Israel. Most of the Negev desert is upland plateaux, at 400–1000 m elevation,

Table 8.3 Average daily temperatures (°C)

Average daily temperature						Average daily maximum temperature						Average daily minimum temperature					
Oct	Nov	Dec	Jan	Feb	Mar	Oct	Nov	Dec	Jan	Feb	Mar	Oct	Nov	Dec	Jan	Feb	Mar
Hazeva, Arava, Israel (30°48′ north at −140 m) 1967																	
25.9	20.1	16.4	13.7	14.5	16.6	31.4	25.7	22.3	19.5	19.8	22.6	20.4	14.7	10.5 7.4[a]	7.8 2.0[a]	9.2 5.5[a]	10.6
Tel Aviv, Ben Gurion International Airport, Israel (40 m) 1951–60																	
21.9	17.9	14.6	12.7	13.0	14.3	29.2	24.6	20.4	18.5	19.1	21.0	14.6	11.2	8.7	6.9	6.9	7.6
Köln, FR Germany (45 m) 1931–44 and 1951–52																	
10.4	6.4	2.6	1.9	2.7	6.0	14.1	8.9	4.8	4.4	5.6	10.1	6.7	3.8	0.3	−0.7	−0.3	1.8
St Albans, Hertfordshire, England (83 m) 1941–70																	
10.5	6.3	3.9	2.9	3.3	5.5	14.5	9.4	6.9	6.8	6.4	9.6	6.5	3.1	1.0	0.0	1.2	1.4

[a]Absolute minimum figures.

Sources: Hazeva and Tel Aviv—Israel Meteorological Service. Köln—*Tables of Temperature, Relative Humidity, Precipitation and Sunshine for the World. Part III—Europe and the Azores*. London, Meteorological Office, HMSO, 1972, p. 46. London—*Averages of Temperature for the United Kingdom 1941–70*. London, Meteorological Office, HMSO, 1976, p. 16.

covered with *hamada* surfaces. They drain to the Rift Valley in the east, where the Arava is at between 100 and 300 m below sea level.[15] On the rare occasions when the wadis are in flood (these floods often being rather violent), the steep drop down to the Rift Valley followed by a sharp easing of gradient causes heavy sedimentation in the valley beds in the Arava. The sandy elements of these sediments form the soil base for the modern agriculture of the region. Unfortunately the areas so cultivated are located in the wadi beds and thereby subject to the same floods which deposited the soil. Arava agriculture is therefore high-risk farming, exposed to flood risk and occasional killing frost, in addition to the normal range of risks, natural and economic, under which all farmers operate.

The north-western Negev, less arid than the Arava, was developed slightly later, when water for irrigation became available from the National Water Carrier. As this was available to the individual farmer in strictly controlled amounts,[10] and in view of the high rates of evaporation in the region, greenhouse farming in a strictly controlled environment became prevalent, thereby reducing the amount of water applied; the water was further re-used by recirculation throughout the agricultural season. As a result, an average family greenhouse farm required 2000–3000 m^3 of water each year, compared with the 10–15 thousand required by a 'normal' farm with open-field agriculture. The north-western Negev, like the Arava, produces vegetables and fruit for the European market and for the major inhabited northern half of Israel.

Greenhouse agriculture detaches itself from soil as a basic natural resource. The greenhouse not only farms a minimal area (under the conditions of the north-western Negev, one-tenth to one-fifteenth of the area of an open-field farm); it does not even farm the local soil, but a sand layer mulched with peat, which is normally imported (mostly from Ireland). Here Israeli agriculture has come full-circle: from traditional dry-farming for which soil was the decisive resource base, to greenhouse farming which transports soil and water in minimal amounts to areas with the commercially most advantageous climate as the decisive resource base.[16]

Israeli farmers did have ample experience with greenhouse farming prior to its widespread introduction into the north-western Negev. Again, agroclimatic considerations had been decisive. The crop grown in greenhouses on a considerable scale were flowers for the export market. It was due to individual initiative that intensive flower farming, mainly of roses, on a commercial scale was introduced at Shachar Village in the Lachish region in the earlier 1960s. The location of the area is not far from the border of aridity,[17] but is still well within the area of mediterranean climate. Greenhouse crops benefitted from the moderate cloudiness and associated high temperatures of the area, while the cooler temperatures at night and during stretches of cool weather were countered by heating the greenhouses

whenever necessary. This permitted—exceptional years excluded—the roses to ripen for the Christmas market in Europe. Farmers in the Lachish region, and those of other areas in Israel who followed suit, use the local soil for greenhouse farming, with some added mulch, not sand trucked to the greenhouse.

8.5 IMPLICATIONS OF INTENSIVE APPLICATION OF CHEMICALS ON THE RESOURCE BASE OF AGRICULTURE

Greenhouse farming, north-western Negev style, with sand as soil had the additional advantage of being very suited to agriculture with an intensive input of chemicals. One should remember that until the early twentieth century agriculture in Israel was not only *dry*-farming but farming almost without fertilizers. Not much livestock was kept in the farm unit, and the way it was kept did not bring about the accumulation of manure. In the days prior to the introduction of trucks and of mechanized transportation in general, camels were still kept in great numbers, roaming over meagre pastures and dispersing their droppings.[18] Following the near-total deforestation of the country in antiquity, charcoal and dwarf bushes (especially *poterium spinosum*[19]), as well as dried manure, were used for heating and cooking. To this day, the Beduin use dried camel droppings in open fires in the preparation of coffee and ceremonial meals.

After the First World War modern agriculture, with Jewish farmers in the lead, applied proper fertilization with manure, both of cattle and poultry, as well as of sheep where kept. Livestock rearing was thus an essential component of 'mixed farming'.

The application of farm manure is, however, rather labour consuming, so by the 1960s the application of chemical fertilizers became prevalent. They had the additional advantages of being more pleasant to handle, they could be mechanically applied, and in their selection and combination could be adapted to the specific requirements of soil and crop. The intensive use of chemical fertilizers and soil conditioners supplied the soil with elements to replace those withdrawn by the crops. Chemical fertilizers therefore permitted the intensification of land use by speeding crop rotation, or even dispensing with it. The farmer could cultivate the same field with the same crop, season after season, without intervening fallow. An outstanding example is cotton, which was known as being rather demanding on the soil. For many years Israeli farmers have grown successive crops of cotton, year after year, without any apparent damage to the soil, owing to adequate fertilization.[20] At the same time Israeli agriculture adopted pesticides; these were even more convenient for mechanized application, often being sprayed from small aircraft.[21]

Nevertheless, the intensive use of chemical fertilizers and pesticides places

a premium on light and permeable soils. The heavier and more impervious a soil is, the more chemical residues it will retain and accumulate over time. The ideal soil for this type of 'chemical agriculture' is a highly permeable one, light and chemically 'neutral'. Pure sand fits these specifications best. 'Chemical agriculture' therefore places a premium on sandy soils, especially pure dune sands of the coastal zone and even more of inland areas.[22] It was for this reason that the large areas of dune sand of the north-eastern Sinai[23] and the adjacent areas of the north-western Negev assumed prime rank for the most modern agriculture, exceeded only by greenhouses operating on allochthonous pure sand.

Chemical agriculture, however, involves another environmental risk, which became evident in Israel in recent years. Irrigation and the rains in winter wash remnants of chemical fertilizers and pesticides into the ground and bring about their enrichment in the groundwater. As groundwater is used for supplying the National Water Carrier, over the years this has become a matter of concern. In particular, nitrate concentrations in the groundwater of certain areas of the coastal plain did reach near-critical values (Shuval, 1980), especially for those sectors of the population with limited tolerance (mainly babies).

A move away from chemical pesticides and fertilizers towards biological methods of pest control and organic fertilization seems due. Should this materialize, it would have implications for land use and land transformation. Whereas recent, most intensive, types of agriculture, with their preference for specific types of light soils, rotated certain lands out of use, and thereby tended to bring about a slight decrease in the total area cultivated, biological pest control and organic fertilization should bring about a renewed expansion of cultivated land.

The need for a very careful and comprehensive appraisal, and for periodic reappraisals, of the environmental implications of land transformation and of development projects is illustrated by the drainage of the Huleh swamps (Karmon, 1960). The Huleh Basin is the northern-most part of the Rift Valley in Israel between the Kfar Gil'adi area in the north and former Lake Huleh in the south. This small and shallow lake (maximum depth barely more than 5 m) was dammed behind a basalt barrier of Neogene–Quaternary age.[24] Upstream, i.e. to the north of the lake, there was a transition to a larger swamp area. This apparently formed only in relatively recent times as a result of the obstruction of the drainage of the Jordan river created by the inadequate opening of a bridge built *ca* 1260. The swamp was certainly not in existence as late as the first century BC when a flourishing settlement existed at Tell Anafa, recently excavated and located in the midst of what later were the swamps.[25]

The drainage of the Huleh swamps had been an objective of Zionist settlement policy since very early this century. This was the area with the

richest surface water resources in Israel. It was obvious that a large amount of water, a precious resource in Israel, was wasted by evaporation from the swamps. Underneath the swamp was deep alluvial soil, rich in organic content, and under this rather thick deposits of peat. The swamp made the Huleh not only unusable for agriculture, but over the centuries it became infested with malaria; and after the drainage of the Kabbara swamps near Hadera in the coastal plain in the 1880s, the Huleh remained the most malarious area of Israel.

It was only in the 1950s that the drainage of the Huleh could be realized, and both the swamps and the shallow Lake Huleh to the south of them were drained and disappeared from the map. (It is ironical that one of the reasons for the drainage project had disappeared in the meantime, when spraying with DDT by the British Army during the later years of the Second World War had eradicated malaria.) On completion of the drainage the Huleh Basin came under agriculture, including some areas of fish ponds (discussed in section 8.3). The water draining off its rich organic soils enriched Lake Kinneret (Lake Tiberias or the Sea of Galilee), 280 m lower and 20 km to the south, with large amounts of phosphorus and nitrate minerals to which the effluents of pesticides and other chemicals used by the farmers were added. This changed the limnologic, trophic balance of the Kinneret, the major intake of the National Water Carrier. For a while, eutrophication of Lake Kinneret seemed threatening and some people had second thoughts on the wisdom of having drained Huleh and eliminated the swamp, which had acted as a natural strainer, preventing too high a mineralization of the Jordan and Lake Kinneret. Some extremists even considered re-flooding the Huleh Basin.[26]

Today a more balanced and sober view prevails and the limnology of the Kinneret is under close control. But the drainage of the Huleh certainly should teach planners a lesson about the need for a most careful and comprehensive appreciation of the environmental consequences of development projects, even if it appears obvious that the project is justified.

8.6 URBANIZATION OF AGRICULTURAL LAND

Land transformations dealt with so far relate only to different types of agricultural land use, to *mise-en-valeur* of land not formerly cultivated, or to abandonment of cultivated land. However, in recent decades more than 90% of the Jewish population of Israel (86.7% of the total population) are urbanized (Table 8.4).

It is obvious that an urban population of this size places considerable demands on land, and by necessity on agricultural land, either land actually cultivated or land potentially suited for cultivation, or rather both. Most cities, and particularly large and fast-growing ones, developed originally as central places of prosperous agricultural areas. The very reason which made the cities

Table 8.4 Percentage of urban population in Israel

	Total	Jewish
1951	–	76.0
1955	70.8	76.4
1961[a]	77.9	84.6
1972[a]	85.3	90.4
1980	86.7	90.4

[a]Census figures.
Source: *Statistical Abstract of Israel* for relevant years.

grow and expand leads, therefore, to them demanding increasing amounts of the same land on which early growth depended. The larger the city, the more far-reaching tend to be the urban transformations of agricultural land. For obvious reasons, in competition for land between the city and agriculture the city prevails.

These general principles apply in Israel as they apply elsewhere. Transformation to urban land use is, therefore, the most extensive and the most serious in the Tel Aviv metropolitan area, inhabited by close to 1½ million people, roughly one-third of the total population of Israel. A map of 1878 shows Jaffa, the ancient nucleus of Tel Aviv, in its setting of citrus orchards and vineyards (Sandel, 1980). Practically every hectare of them is today within the built-up area of the conurbation. The same applies to Haifa and to the other cities of Israel, although to a lesser degree.

As stated before, the state of the Tel Aviv metropolitan area refers not only to the largest item of transformation of agricultural land to urban use, but is the most serious as well. The reason is the transformation to built-up land of prime citrus orchards, producing for a hundred years Israel's first-ranking agricultural export crop. The same, although to a lesser degree, applies to other cities of the coastal plain. For the same reason, transformation to urban use is less serious from the point of view of the national economy in the case of the upland towns, such as Jerusalem, the Carmel sections of Haifa, Safed, Bethlehem, Nablus, or some of the New Towns like Karmiël or Ma'alot. Jerusalem today covers 50 times the area of the Old City, within the walls of which all Jerusalem was confined until 1860; but with one insignificant exception all of the New City is built on what in mandatory terminology was classified 'rocky ground'—some of it never cultivated before, the rest unused for agriculture for many centuries and unsuited to agricultural cultivation under present socio-economic conditions.

In recent years a new element of land use emerged in the uplands, viz. a sizeable number of non-agricultural settlements, most of them classified *rural*, a few of them towns. The majority of their gainfully employed population are

commuters, working in the metropolitan areas or medium-size towns. The proximity and easy access of the Tel Aviv metropolitan area from places in Samaria, that of Haifa from Galilee, and Jerusalem from the Judean Highlands, make commuting convenient. By the end of 1981 there were some sixty such non-agricultural settlements, established in the preceding 10 years, including six towns.[27] Most of these 'rural settlements' were classified as *community settlements* (yishuv kehilati) or *industrial villages* (kafat, the abbreviation of Kfar ta'asiyati), adding to the variety of standard village types in Israel: *moshav*, the cooperative village; kibbuts, the communal village, all these on state-owned land;[28] and the *moshava* as well as the Arab *village* which are regular villages with private ownership of land and no in-built cooperation.[29]

Several reasons combined for this significant expansion of non-agricultural settlement into the upland districts of Israel. The high ratio of urbanization makes urban build-up a necessity. At the same time the adverse effects of crowded urban environments and of deterioration in many an older section of cities are a strong impetus to move to a better and cleaner physical and social environment. With rising standards of living they induce many a family to migrate from urban to rural areas. In this respect the uplands have several advantages over the lowland plains. Their summer climate is more agreeable than that of the warm and often humid plains. Considering rational land use, the rocky uplands do not compete with agricultural land. They are therefore cheaper and more easily obtainable for residential housing than the agricultural land of the plains. Finally, for a certain sector of population there are political reasons for moving to Samaria and Judea.

Not all the working population of the non-agricultural villages commute to places of work elsewhere. Apart from the *industrial villages* a number of the other rural places, even some of those that engage in agriculture, have one or more industrial plants providing some local employment. In most cases they are of small size, often quite specialized and sophisticated: electronics, fine mechanics and science-based industry are amongst branches represented.

To sum up, we find a whole range of motives for the spread of the population engaged in urban occupations into non-agricultural rural places and towns in the uplands, most of them commuting to work. These motives include: easy commuting accessibility; rational use of rocky land unsuited for agricultural use, which is therefore relatively cheap; an advantageous climate; a rural environment conducive to a better quality of life; and finally, at least in Samaria and Judea, motives of political ideology. This last motive is of particular practical importance. It applies not only to part of the population who moved into Samaria and Judea,[30] but to the present government of Israel (in power since 1977). In order to advance Jewish settlement in these areas, people who move there enjoy considerable advantages in mortgages, loans and often subsidized costs of construction and infrastructure. These economic

advantages result in the migration into these upland places of many families whose motives are pragmatic rather than ideological.

The problematic aspects of transformation of agricultural land to urban land use, therefore, centre in the lowland plains, the agricultural region of relevance in the Israel of today. Here it is a matter of concern, and should be a matter of even graver concern to the national planner the responsibility of whom is planning for future development.

But the effects of expansive urbanization concern not only the urban areas proper. Cities and their urban population have a socio-economic spillover effect, the geographical expression of which is urban sprawl. Urbanites move as residents into villages, creating conflicts in land use with the activity of farmers (cf. Chatham and Griffin, 1958, especially p. 202). In addition, urbanites, especially the inhabitants of large cities, require considerable areas of the rural realm as recreational areas—for hiking, picnic areas, sports grounds and a variety of activities—all of which tend to clash with agricultural activity.

An additional essentially urban contender for rural land is industry, which for reasons of its own[31] either relocates from cities into the countryside or is established at rural places, sometimes by or for the rural population, in an age of diminishing employment in agriculture resulting from increasing mechanization. While agriculture mainly requires soil of good productive quality, towns require a certain area, in which good drainage and a relatively moderate topography are of advantage but not a *sine qua non*. Soil of productive quality is of no concern. Logic should, therefore, allot agriculturally productive soils to agricultural use and locate cities off such soils. For a great number of reasons, real-life conditions are different, and sometimes the exact opposite. As good agricultural land is limited in extent, this must be a matter of concern.

8.7 THE *SEVEN EARTHS* OF ISRAEL

The heading of this section borrows a phrase from the title of a classic paper by Edward Higbee (1952). Israel is an outstanding example illustrating that the same earth—the same natural resources—are put to different uses by different people, employing different technologies. Israel illustrates that land of great value to one population was entirely useless to another one, and was even considered anecumene, i.e. outside the area potentially cultivable. Different people employing different technologies have been using the land of Israel in seven different ways.

The *First Earth* apparently was the coastal plain and the inland basins, including locations in the Jordan[32] and Beth Shan Basins where very early agricultural settlements have been studied by archaeologists. Agriculture in these areas, apparently, was the regular type of cultivation—mainly dry-

farming with occasional irrigation using the water of local springs. At least in the coastal plain, settlement and cultivation required occasional drainage to remove swamps. Drainage works were installed by Roman engineers in the first centuries AD.

In part concurrent with this stage, but agro-technically much more complicated and as far as the size of the enterprise is concerned much more ambitious, was the *mise-en-valeur* of the *Second Earth*. This was the transformation of the deforested and denuded upland slopes into agricultural terraces (discussed in section 8.2). This was part of a general mediterranean culture trait, as were the crops cultivated on the terraces: olive trees, other fruit trees such as figs or apricot, grapes, and cereals, mainly wheat. Installation of these terraces required an extraordinary input of manual labour; their maintenance required a well-functioning social structure to ensure proper maintenance of terrace walls and of drainage spillways. It is assumed that this terrace culture dates to the first millennium BC and to most of the first millennium AD. Evidence of ancient settlement proves that both the First and the Second Earth supported a rather well-to-do population.

Concurrent in part with these two cultures, but in an entirely different region of Israel, we find the *Third Earth*, the Nabatean desert agriculture (also discussed in section 8.2). In many ways this is intellectually the most fascinating 'Earth', highly unconventional and innovative. Whereas the First and Second Earths cultivated the normal cultivable land of Israel—its standard ecumene being the northern half of Israel with mediterranean climate where the semi-humid climate created natural soil and adequate winter rains permitted cultivation—the Third Earth was in the Negev desert. Except for oases, where water is provided locally by nature, the Negev, like all deserts, is considered anecumene, i.e. land not only uncultivated, but unsuited for agriculture owing to the absence of both soil and water, a consequence of the arid climate. With the exception of some occupation in prehistoric times—in the third millennium BC, which did not in any way approach the sophistication of Nabatean agriculture[33]—the central Negev was definitely anecumene after the demise of this culture until the 1950s, and concerning the core area of the Third Earth remains so to this day. The Nabatean settler was an admirable observer of nature and had an acute understanding of its mechanism. He chanelled water, and with it soil-forming elements of the ground, on to wadi beds, a location rightly avoided by farmers in other regions of Israel. He developed a technique by which the rare and extremely irregular rains of the desert soaked into the field and thus permitted crops to grow. Nabatean agriculture was not discontinued owing to a deterioration of nature nor of its resources, but to changes of a socio-economic nature which shifted regional preferences. This sophisticated agricultural management of the arid Negev is a part of a wider culture trait. Evidence of similar types of ancient agriculture is found in various areas of the Middle East, from Yemen to Cyrenaica in present-day Libya.

Whereas the First and especially the Second and Third Earths of Israel represent periods of prosperity and development, the *Fourth Earth* is the period of regression and of deterioration of the land resource discussed earlier. It began late in the first millennium AD and lasted to the late nineteenth century. For more than a thousand years the Third Earth reverted to desert. Farmers of the Fourth Earth made but poor and reduced use of the First and the Second Earths, both of which deteriorated sadly and to an increasing degree. It is highly significant that, at least during the later stages, farmers of the Fourth Earth had considerably reduced, or even abandoned, cultivation of the fertile First Earth, the plainlands, most of them having withdrawn to cultivating upland terraces. Even here, cultivation fell considerably short of that of the Second Earth, both by area cultivated and by deterioration of the terraces and their maintenance. In the absence of irrigation, heavy (mostly alluvial) soils or basaltic soils in the north-east were the preferred substratum for agriculture. These were the centuries of decay when the land of Israel turned into an impoverished, malaria-stricken country, suffering both from maladministration and from a backward population. At this stage the total cultivated area reached its minimum and the population declined. The under-use of the plains with their naturally fertile resource base is illustrated by the distribution of urban centres. In the nineteenth century six of the ten first-ranking towns, including the country's largest one, were located in the uplands. By the end of the British mandate (1948), four only of the ten first-ranking towns, including the second ranking one, were still upland towns.[34]

The pioneer settlers of the outgoing nineteenth century, and to an increasing degree their successors during the first half of the twentieth century, brought about decisive improvements, creating with enterprise and modern agricultural techniques the prosperous *Fifth Earth*. Large-scale projects reclaimed the land which had deteriorated throughout centuries. Irrigation was introduced at an ever-increasing scale, and for the first time modern mechanized farm implements became standard equipment. Consequently, and in contrast to the preceding stage, emphasis in cultivation reverted from the uplands to the plains. As irrigation expanded so did the extent of cultivated land, both in area—mainly into the southern parts of the coastal plain—and in type of soil, with the *mise-en-valeur* of the light sandy soils. Throughout this period farming diversified, expanded and consolidated.

The next stage, the *Sixth Earth*, dates to the second half of the twentieth century. In common with the Second Earth of terrace construction and cultivation in the uplands, but somewhat less than the Third Earth of the Nabatean farmers of the Negev, the Sixth Earth represents a highly unconventional and novel approach to land use and to agriculture (discussed in section 8.4). Its technique is highly mechanized and involves, therefore, a pronounced reduction in manpower employed. In contrast to all previous approaches, land now ranks as a secondary resource base. By now subsistence

agriculture is a matter of the past. The market directs agricultural planning. The possibility of introducing out-of-season agriculture in the Negev in order to produce during the winter fresh products for the European market makes the climate—especially high temperatures coupled with clear skies—the first-ranking resource, and shifts regional preferences once more into the Negev, although into areas different from those of Nabatean agriculture. Soil is cultivated irrespective of the inherent risk of flooding, and water is piped to the optimal place of use rather than made use of where it occurs in nature.

Elsewhere in Israel, the National Water Carrier ranks water higher than soil as a resource in farming. It is used where each cubic metre gives the highest return. In extreme cases, soil too is used as an *artificial* resource, not *in loco*, but at the climatically optimal location in greenhouse farming. This again tends to give regional preference to the north-western Negev with its clear skies. In addition to advanced genetic research improving strains of crops, chemicals have largely taken over as fertilizers and pesticides, both for convenience of handling and in particular to intensify cultivation. This obviates, if so desired, the need for crop rotation. The intensive use of chemicals has placed a premium on light, permeable and chemically neutral soils which retain a minimum of the chemicals applied. Pure sandy soils, including dune areas formerly considered of no agricultural value, are now particularly in demand. Therefore, the coastal dunes came into the orbit of agriculture, as did the inland dune areas of the northern Negev. The increase of intensity of cultivation, more discriminating as regards the properties of the soil, restricts cultivation to the more desirable soils and reduces to a certain degree the total cultivated area. Yields and size of crop are no longer determined mainly by the size of area cultivated, but rather by modern agricultural technology, its chemicals and genetic improvements.

After the end of the First World War a very different type of land use and land transformation emerged, making gradually increasing demands for often potentially fertile and even cultivated land. This is the urbanized *Seventh Earth*. As about 90% of the population require this type of land use today, the tendency for and pressure of its expansion are considerable. To quote Higbee (1952): 'What is of value to urban man is tended to satisfy his wants and suit his tastes; the rest is neglected.' In view of the fact that much of the land involved in urban transformation is of prime agricultural value, this is a matter of considerable national concern.

8.8 REVERSIBLE AND IRREVERSIBLE CHANGES OF LAND USE

An attempt was made in section 8.7 to show how different populations employing different agro-technologies utilize the same land. We have seen times of improvement and of positive changes in land use alternating with times of deterioration, and even of desertification. The example of Israel

might be important in showing that in a region, without any physical changes involved, deterioration in land use with negative effects on the resource base might follow periods of significant improvement and be followed in turn by another positive change, provided that the period of deterioration did not destroy the resource base, and thereby bring about irreversible changes.

In surveying the range of changes in land use in Israel, one can note many important but reversible changes in land use, and irreversible ones as well. Swamps in the lowlands and valley beds which were clogged have been drained, malaria was eradicated, upland slopes which were deforested and denuded were transformed into agricultural terraces; many of them were recently reforested and serve now as recreation areas. But examples are not missing on the debit side. Upland deforestation brought about soil erosion which can be but partly redressed by re-afforestation. In the conditions of Israel, soil of natural quality and depth does not reform, at least during the period of human planning. Overuse of the coastal plain aquifer has, in three areas,[35] brought about penetration of seawater into the groundwater—a change if not completely irreversible, at least irreversible for a prolonged period of time. The same would apply to the excessive enrichment of the coastal aquifer by nitrates, at least locally, should the suspicions of some experts materialize. This is a typical case of environmental overload, leading to severe economic consequences concerning acceptance by the market of the products grown under these conditions.

No negative environmental change bringing about worsening conditions has been *planned* intentionally. They are the unintentional results of incompetently or incompletely planned actions by man. As they result from intentional actions they are examples of *planning by default*.

The most recent, areally considerable and qualitatively serious, case of planning by default concerns urban expansion. No one intentionally brings about the expansion of the built-up area of cities, that of the urban fringe, nor of urban sprawl into the rural countryside on to valuable agricultural land. In a majority of cases the built-up area even succeeds land actually under agricultural cultivation. In the case of urban expansion, planning of the city and agricultural planning are the task of and are in the competence of different agencies, which not only base their activities on very different premises, but also operate at vastly different speeds, and generally at very different economic levels, and under very different socio-economic pressures. For obvious reasons, in a conflict of interest between city and agriculture, the city prevails, representing much more powerful interests, both economical and political. The result is therefore a special case of planning by default, created by an inbuilt mechanism of compartmentalized planning which lacks coordination to balance two very unequal contenders in order to safeguard the optimal long-term national interests.

The transformation of agricultural land to urban uses, though being of

minor importance in terms of the areas involved, is today in many countries the most active process of land transformation. This certainly is the case in Israel. Of all the processes of land transformation this is by realistic appraisal the most irreversible one. In view of the global nature of present-day urbanization, all this applies *grosso modo* in most advanced or strongly developing countries anywhere.

8.9 REFERENCES

Amiran, D. H. K. (1960) Two types of border aridity in Palestine. *Compes rendues, 18th Int. Geograph. Congr.*, Vol. II, Rio de Janeiro, 461–465.

Amiran, D. H. K., and Kedar, Y. (1959) Techniques of ancient agriculture in the Negev of Israel. *Comptes rendues, 18th Int. Geograph. Congr. 1956*, Vol. I, Rio de Janeiro, 206–217.

Amiran, D. H. K., and Shahar, A. (1961) The towns of Israel: the principles of their urban geography. *Geograph. Rev.*, **51**, 348–369.

Atlas of Israel (1970). Elsevier, Jerusalem and Amsterdam.

Bar-Yosef, O. (1973) Early man in the Jordan Valley: the excavations at 'Ubeidiya. *Archaeology*, **28**, 30–37.

Bitan, A. (1974) Climatological aspects in locating settlements in arid regions. *Geoforum*, **20**, 39–48.

Bitan, A. (1982) The Jordan Valley project: a case study in climate and regional planning. *Energy & Buildings*, **4**, (1), 1–9.

Chatham, R. L., and Griffin, P. F. (1958) Urban impact on agriculture in Santa Clara Country, California. *Annals of the Ass. of Amer. Geographers*, **48**, 195–208.

Cressey, G. B. (1958) Qanats, Karez and Foggaras. *Geog. Rev.*, **48**, 27–44.

Eliav, M. (1977) The Rafah Approaches in the history of Jewish settlement. *Cathedra*, **3**, 117–208 (in Hebrew).

Evenari, M., Shanan, L., and Tadmor, N. (1971) *The Negev*. Harvard University Press, Camb., Mass.

Gradmann, R. (1934) *Die Steppen des Morgenlandes*. Engelhorn, Stuttgart (Geogr. Abh., 3R, H6).

Herbert, S. (1978) Tel Anafa. *Israel Exploration Jl*, **28**, 271–274.

Herbert, S. (1982) Tel Anafa—a further report. *Israel Exploration Jl*, **32**, 59–61.

Higbee, E. C. (1952) The Three Earths of New England. *Geog. Rev.*, **42**, 425–438.

Ilan, Z. (1973) *The Jordan Valley and the Samarian Desert*. Am Oved, Tel Aviv.

Karmon, Y. (1960) The drainage of the Huleh Swamps. *Geog. Rev.*, **50**, 169–193.

Kedar, Y. (1967) *The Ancient Agriculture in the Negev Mountains*. Bialik Intitute, Jerusalem (in Hebrew).

Nir, D. (1959) Artificial outlets of the Mount Carmel Valleys through the Coastal 'Kurkar' Ridge. *Israel Exploration Jl*, **9**, 46–54.

Porat, Y. (1970) Chain wells in the Jordan Valley. *Teva ve-Aretz*, **12**, 128–132 (in Hebrew).

Reifenberg, A. (1955) *The Struggle Between the Desert and the Sown*. Bialik Institute, Jerusalem.

Ron, Z. (1966) Agricultural terraces in the Judean Mountains. *Israel Exploration Jl*, **16**, 33–49 and 111–122.

Sandel, T. (1980) Karte der Umgebung von Jaffa, 1:31 000. *Zeit d. Deutsch. Palästina Vereins*, **2**, Tafel III. Reproduced in *Atlas of Israel*, op. cit., sheet XI/4, map B.

Shuval, H. I. (1980) *Water Quality Management Under Conditions of Scarcity: Israel as a Case Study*. Academic Press, New York (especially chap. 13.III).
Sorre, M., and Sion, J. (1934) *Géographie Universelle*, VII, Pt. I: *Méditerranée*. Armand Colin, Paris.
Spencer, J. E., and Hale, G. A. (1961) The origin, nature and distribution of agricultural terracing. *Pacific Viewpoint*, **2**, 1–40.
Statistical Abstract of Israel (1981) Vol. 32, tables XIII/2 (pp. 382–383) and XIII/4 (p. 385).
Troll, C. (1963) Qanat-Bewässerung in der Alten und Neuen Welt. *Mitteil., Oesterr. Geograph. Ges. Wien*, **105**, 313–330.
Yair, A. (1983) Hillslope hydrology water harvesting and areal distribution of some agricultural systems in the northern Negev Desert. *J. of Arid Environments*, **6**, 283–301.
Zohary, M. (1955) *Geobotany*. Merhavia, Pt. IV-b (in Hebrew).
Zohary, M. (1970) Vegetation of Israel and adjacent areas. In: *Atlas of Israel*, op. cit., sheet VI/1, map A.

8.10 NOTES IN THE TEXT

(1) Josephus Flavius: *de Bello Judaico*, V, paras. 522 and 523. I am indebted to D. Bahat of the Department of Antiquities, Israel, for this reference.
(2) Jerusalem, a walled city, was subjected to a Bediun raid as late as 1820 and the Turkish governor held for ransom. By the middle of the nineteenth century the large inland plains of Yezre'el (Esdraelon of the English Bible) and Beth Shan were frequently raided by Bediun from Trans-Jordan.
(3) A recent attempt to create broader terraces, connected by ramps to allow the movement of mechanical equipment from terrace to terrace, and to cultivate these by irrigation, was not overly successful.
(4) There is no indication that in Nabatean times rainfall was more ample than today.
(5) Most of Nabatean settlements in the Central Negev were towns.
(6) Lands of the coastal plain were relatively readily available as the great majority of the population lived in the uplands, in distinct contrast to present-day conditions. They had abandoned the lowlands for being swampy and malarious, as well as for suffering from poor security. They, and no less the rich absentee landlords who owned much of the land, were only too glad to sell it to whomever made a worthwhile bid for it.
(7) There was little thought of settling the arid south at the time. The major exception was a project for settling the el-Arish area in Sinai; this was investigated by a mission of experts in 1903, who eventually submitted an adverse report cf. Eliav, 1977).
(8) Sugar cane was grown successfully in the Huleh Basin, but was discontinued as being uneconomic for its high water consumption. Poultry—chicken and turkey—are today the main source of animal protein in the Israeli diet.
(9) *Atlas of Israel*, op. cit., no. 1, sheet IV/2, for maps of inter-annual variation of rainfall; and sheet 13 in the forthcoming third edition.
(10) The amount of water available to every village, and beyond that to every agricultural unit, is determined annually in very strict allotments by the Water Commissioner, a senior official of the Ministry of Agriculture.
(11) These topo-climatic conditions make it for man physiologically harder than the climate of the Negev. See Amiran (1960) and Bitan (1974).

(12) See *Atlas of Israel*, op. cit., no. 1, sheet VIII/2, maps B and D.
(13) The latter is of critical advantage under the climatic conditions of Israel.
(14) 18–87 mm per year during a 10-year period at Hazeva in the Arava.
(15) The base level of erosion is the Dead Sea, the level of which has an elevation of approximately −400 m.
(16) A secondary advantage of the unconventional agriculture of the Negev is that it cultivates 'empty' areas not in use, as these lands could not be cultivated by agricultural technologies employed previously. On a different level, pest control is much easier in a controlled environment. Finally, the proximity of the farmhouse and the greenhouse—as it were, the *field*—enables the farmer's wife and children to work in the greenhouse for short periods whenever they can afford to do so.
(17) The average annual rainfall is slightly less than 400 mm.
(18) Until the First World War the camel was the main means of transport in Israel and throughout the Middle East. Vast numbers of camels were kept. This was the essential reason for the persistence and for the social prestige of the nomadic Beduin before the war. They not only provided camels for long-distance transportation; they also organized, serviced, guided and protected the caravans—and by mutual tacit agreement robbed them, or at least extorted protection money, if they did not hold travellers for ransom. The advent of motorized transportation—the bus and in particular the truck—made the camel obsolete, and with it the traditional way of life of the Beduin. After the First World War bediun society underwent a severe economic crisis and decrease in social status. Herds of camels decreased, both with the Bediun and the villagers, the fellaheen (Table 8.5). The Bediun soon adopted the modern way of life and integrated into its economy.

Table 8.5 Camels in Israel

1922	19 225
1932	23 317
1942/43	29 736
1958	11 000
1964	10 500
1971	10 000

Sources: *Statistical Abstract of Palestine*, 1937–38, and *Statistical Abstract of Israel* for relevant years.

(19) *Poterium spinosum* represents the last stage in deterioration of the climax vegetation of a mixed mediterranean forest. Until the 1940s it was collected in large loads, transported by women on their heads, to be used for domestic heating and especially to fire lime kilns, which demanded large amounts of the shrub.
(20) In 1979/80, 24% of the field crop acreage of Israel was in cotton. The total cotton acreage exceeded that of citrus by 57% (*Statistical Abstract of Israel*, 1981).
(21) A number of commercial firms operate a fleet of small aircraft for agricultural spraying operations.

(22) These are beyond the reach of salt spray which by aerial transportation reaches the dunes nearest to the coast.
(23) Here intensive farming went on for over a dozen years in the 'Yamit Region'. It ceased when the region was returned to Egypt under the peace settlement in April 1982.
(24) See *Atlas of Israel*, op. cit., no. 1, sheet III/1, Geological Map, by L. Picard.
(25) Herbert (1978) reports: 'Luxury products . . . abound in the Hellenistic levels . . . (and) reinforce this impression of wealth and conspicuous consumption in the Hellenistic period.' This is certainly a very different picture of the malarious swamp existing there for many centuries until 1950. Cf. Herbert's further report (1982). According to Karmon (1960, p. 173), settlement in the Huleh Basin continued uninterrupted until the thirteenth century.
(26) In view of the experience gained one should be more than careful when considering proposals to mine the apparently thick peat deposits of the Huleh Basin. This has been suggested as a possible energy source to fuel a power plant. Presumably, such mining operations would result in surface subsidence which, even if slight, would have serious consequences for the drainage of the basin.
(27) Two additional towns had been established in Galilee in the 1950s and 1960s. By 1980, Karmiël, the larger of the two, had a population of over 13 000.
(28) The few collective moshavim, *moshav shitufi*, adhere to the moshav principle in community structure and to that of the kibbuts in the operation of their economy.
(29) Some Arab villages retain to this day *mush'a* ownership, whereby village land is owned by all land-owning families in common. The individual lots are redistributed for cultivation to all property-right owners every 1–3 years to enable every family in its turn to benefit from cultivating fields more favourable for soil or location.
(30) It must be noted again that the same process of establishing non-agricultural, as well as agricultural, settlements progresses in recent years in the uplands of Galilee, including mountainous Upper Galilee, where no political motives are involved.
(31) The factors might be fiscal, such as taxation and cheap prices for land, or a more pleasant environment, availability of labour and sometimes their wage levels, accessibility, and other factors.
(32) The oldest settlement traced in Israel is the Ubeidiya site slightly south of Lake Kinneret in the Rift Valley, where man lived about one million years ago.
(33) In the present context, this term refers to successive periods as well, until Byzantine times, i.e. the time span from the first century BC to the later part of the first millennium AD.
(34) Ranking data are for 1875 and 1944 respectively. Cf. Amiran and Shahar (1961, especially p. 358).
(35) The Tel Aviv area, that of Gaza, and Emek Hefer near Hadera.