NRTS-10/UNUP-190

Perception of Desertification

Edited by R. L. Heathcote

THE UNITED NATIONS UNIVERSITY

From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions. . . .

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CONTENTS

1. THE CONTEXT OF STUDIES INTO THE PERCEPTION OF DESERTIFICATION

R. L. Heathcote

Most studies of desertification acknowledge the role of human activity in affecting and often initiating the process. That human activity is in response to a variety of decisions on, and systems of, resource management. An understanding of those decisions should therefore help explain the role of human activity in the desertification process – in effect help to explain why resource management in this case seems to be leading to resource deterioration, if not destruction. The aim of this monograph therefore is to provide studies of resource management in four areas where desertification is said to be occurring and to try to document the role of perception of desertification in the decision-making on resource management. In this way it is meant to provide evidence of the methods by which studies of environmental perception can illustrate the human role in the desertification process.

This first chapter provides the context for these studies within the broad research activity in environmental perception, and the final chapter attempts a general summary of the findings from the four studies and suggests specific lessons which might be borne in mind by decision-makers attempting to mitigate the impact of desertification in the study areas as well as lessons which have a more general relevance.

The Behavioural Revolution and Environmental Perception Research

Since the mid-1960s the so-called "behavioural revolution" in geography has produced studies focused upon the ways in which information about the environment is acquired, interpreted, and used in human decision-making. Two broad avenues of enquiry appear to have opened up as a result of this revolution. One, carrying on from the prior quantitative revolution, has led to studies of human spatial behaviour and attempted explanations of the patterns by models and theories derived from physics and mathematics (Abler, Adams, and Gould 1971; Chorley and Haggett 1967). The other avenue has led to studies of human perception of the environment, seeing in expressed attitudes, knowledge, and motives the keys to the understanding of human activity in the environment (Brookfield 1969; Saarinen 1974). The search for relevant data crossed into the field of psychology and met psychologists emerging from their laboratories to tackle the more complex environments of the "real" world outside. The result has been studies of sensory stimuli on a new and broader scale – studies in fact of environmental psychology (Craik 1970; Ittelson *et al.* 1974).

The complex of research resulting from this inter-disciplinary effort has provided three themes which appear to be particularly relevant to the perception of desertification. First is the concern for the historical and sociological context of the perceptions. The management of resources has been shown to have a long and varied history, one in which the contemporary "climates of opinion," philosophies, and cultural viewpoints have played significant roles (Buttimer 1974; Glacken 1967; Tuan 1974). The second theme has been the recognition of the role of images in the decision-making process. Decisions appear to be made in response in part to an "image" of the environment which may differ appreciably between decision-makers and from the "reality" as interpreted by others (Downs and Stea 1973; Lynch 1960). Such images have been shown to be relevant to the understanding of environmental management and planning (Saarinen 1976).

The third theme has been a concern for human perception of, and adjustment to, natural hazards. Here, a considerable body of empirical and theoretical data has been accumulating over the last 20 years and is currently being consolidated in various publications (White 1974; Burton, Kates, and White 1978; Burton and Whyte [in press]). These studies are particularly relevant to the problem of desertification since they have shown that the natural hazards exist at the interface between the natural event system (rainfall data, wind speed, river level, etc.) and human activity (agriculture, buildings, canal systems, etc.). Further, they have demonstrated that the impact of the hazard and the human adjustments to it depend in part upon the perception of the hazard by the people at risk. All the evidence from the studies of desertification so far published seems to indicate that the phenomena of desertification reflect a very similar interface between natural events and human activity. Therefore the hypotheses, techniques, and even some of the findings from the natural hazards studies may be directly relevant to any attempt to understand human appraisal of and reaction to desertification.

The Problem Defined: The Role of Environmental Perception in the Desertification Process

In the context of these prior studies and with particular reference to the three themes noted above, the four case studies reported here were designed to try to establish the role of environmental perception in the desertification process. The studies posed three basic questions:

1) What are the perceptions of desertification, do they vary, and if so, how and why?
2) Do the perceptions of desertification affect reactions to it, and if so, how and why?
3) Does an understanding of the perception of desertification provide any lessons for the mitigation of the deleterious effects of the process?

These three questions should be borne in mind during consideration of the following chapters. The concluding chapter will attempt to provide some general answers.

The Method

The four studies had common aims — the three basic questions noted above — and a common general methodology. This methodology incorporated both structured[1] and unstructured field interviews with a wide range of resource managers (from primary managers — farmers and graziers — to researchers and bureaucrats); documentation of desertification from official statistics, air photographs, and field evidence; and archival study of past production and land-settlement trends. The emphasis on these methods and sources varied in content from study to study due to time constraints and to the availability and relevance of the data. The intention throughout, however, was to obtain a wide spectrum of data both to provide a balanced overview and to avoid some of the problems and criticisms of the original natural hazards research voiced in Downs 1970, Waddell 1977, and White 1974 (180–184).

As defined by Dregne desertification implies: "impoverishment of arid, semi-arid and some subhumid ecosystems by the combined impact of man's activities and drought" (Dregne 1977, 324). Thus a process of interaction between a natural event system (drought) and a human activity system (resource use) which creates resources can also create a hazard — an environmental stress situation — e.g., desertification (Fig. 1.1). Most studies of desertification have concerned themselves sooner or later with soil erosion, seeing this as an index of the relationships between climate, water balances, and biotic forms on one side and human land use systems on the other.[2] In three of the following studies the main emphasis is upon the perception of soil erosion as a surrogate for the broader impact of desertification; in the fourth study the emphasis is upon perception of surface water salinity — another aspect of the

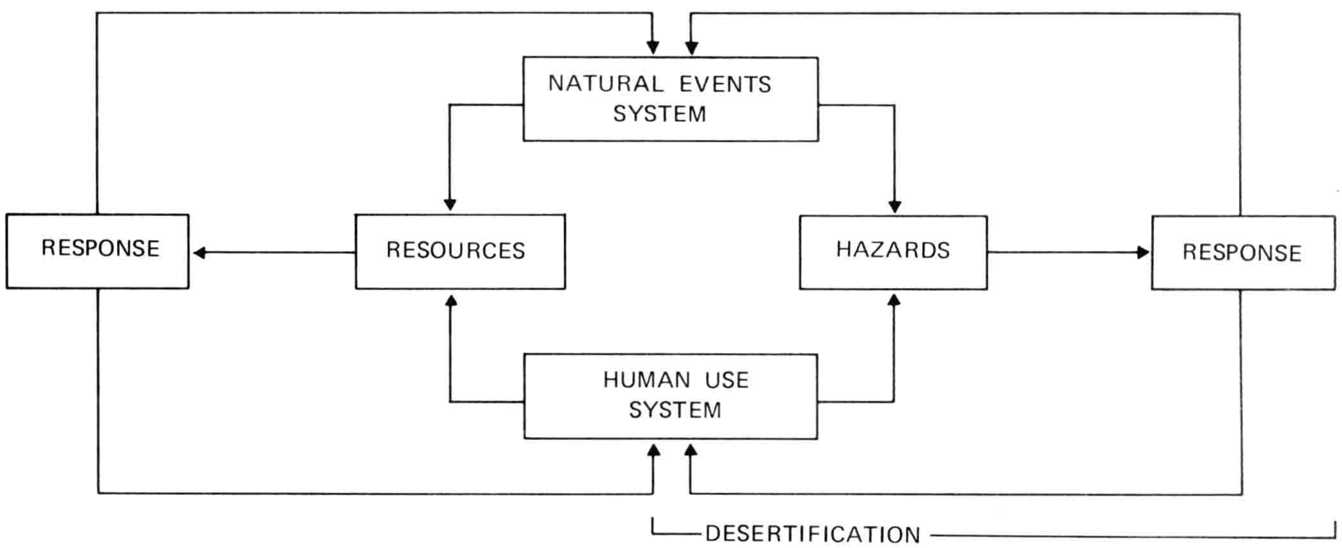

FIG. 1.1. Model of the Interaction between Natural Events and Human Activity

Note: The location of the desertification process is indicated.

desertification process. Three of the studies were concerned with the developed world (Australia and the USA), while the fourth was set in the developing world (Sri Lanka). Each study therefore has a specific aim and spatial-temporal context. Together they may offer evidence of the significance of environmental perception in the desertification process and some ideas on how that perception may be used to mitigate desertification.

Notes

1. Three of the studies made use of a modified version of the original cross-cultural field questionnaire used in the natural hazards research (White 1974, 6–9). Time constraints prevented its use in the Great Plains study.

2. See for example the papers in *Economic Geography* 53 (4), which provide several general reviews as well as case studies of desertification.

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2. DESERTIFICATION IN THE DRY ZONE OF SRI LANKA

M. U. A. Tennakoon

Desertification: The Problem of Definition

As the field of desertification study is still in its infancy, problems of definition are inevitable. Most of the initial studies of desertification have been made on the arid desert margins where the ecosystems have often been changing for the worse in recent times. The outward expansion of desert characteristics is due to climatic and/or biotic changes. Among those harsh desert characteristics impinging on the adjacent areas are: the rapid drying up of already limited surface water resources accelerating aridity; the dwindling of available underground water and the deterioration of the quality of that water, often with increasing salinity; the destruction of surface soil due to wind erosion; sheet erosion following rain; increasing saltiness in surface soil; and the general deterioration of natural vegetation as well as cultivated crops. Studies made on such aspects have come to be regarded as desertification studies, and most scholars have been content with highly general definitions such as "desertification means the spread of desert-like conditions in arid and semi-arid areas due to man's influence and climatic change" (Rapp 1974). These definitions have been refined from time to time.[1]

Definitions have often been points of conflict among scientists. In the continuing effort to further refine their definitions, some scientists have made them more rigid than necessary. Mensching and Ibrahim (1976) defined desertification as "the extent of desert-like conditions as a result of man's impact on the ecosystem of semi-arid areas." They further stated that "concentration has to be in the semi-arid zone where the interactional damages are heaviest [and] analogous changes elsewhere, for instance in the humid tropics are irrelevant [and that] one should not list every anthropogenic impact on ecosystems under desertification."

Undoubtedly, the growing field of desertification owes its origin to a series of systematic investigations made on some of the characteristics of the hot deserts expanding into the neighbouring semi-arid areas. Therefore, there need not be any dispute in giving the studies on desertification process in semi-arid areas the pride of place in the field of desertification studies. But there seems to be no compelling reason to restrict the desertification studies only to the semi-arid and desert margins. If the desert-like conditions begin to appear even in the relatively more humid areas beyond the desert margins, largely due to biotic reasons, studies on such characteristics outside semi-arid areas could be treated under desertification studies.

From a global perspective, the desertification characteristics in areas outside the desert margins may appear to be less significant. Nevertheless, locally and regionally even outside the desert margins, such characteristics have importance to the ecosystem as a whole and on the day-to-day lives of the people in particular. Desertification studies should not, therefore, end strictly where the desert margins disappear. It is with this plea that an attempt is made here to examine some of the elements of the desertification process that have emerged in recent times in the Dry Zone of Sri Lanka.

The Dry Zone Environment

Sri Lanka has varying climates from semi-arid to mild temperate within its area of 70,000 km^2. The mild climates are in the Central Highlands and are largely due to altitudinal effects. However, it is the rainfall which largely determines the climatic variations, notably in the lowlands below 300 metres. The average annual rainfall in the island varies very widely, from about 635 mm in the northwestern and southeastern littoral belts to over 5,000 mm in the southwestern slopes of the Central Highlands (Fig. 2.1).

The Dry Zone Defined

Based on the average annual rainfall, the island is divided into three main zones (Cook 1932; de Silva 1952):

1) The Arid Zone, where the average annual rainfall is between 635 and 1,250 mm, is physically divided into two parts – the northwestern and southeastern littoral belts.
2) The Dry Zone proper, where the average annual rainfall varies between 1,250 mm and 1,900 mm.
3) The Wet Zone, which receives more than 1,900 mm of rain per year.

As subsistence agriculture is the main form of land use in both the Arid Zone and the Dry Zone proper and the farming problems in both zones are more or less similar,

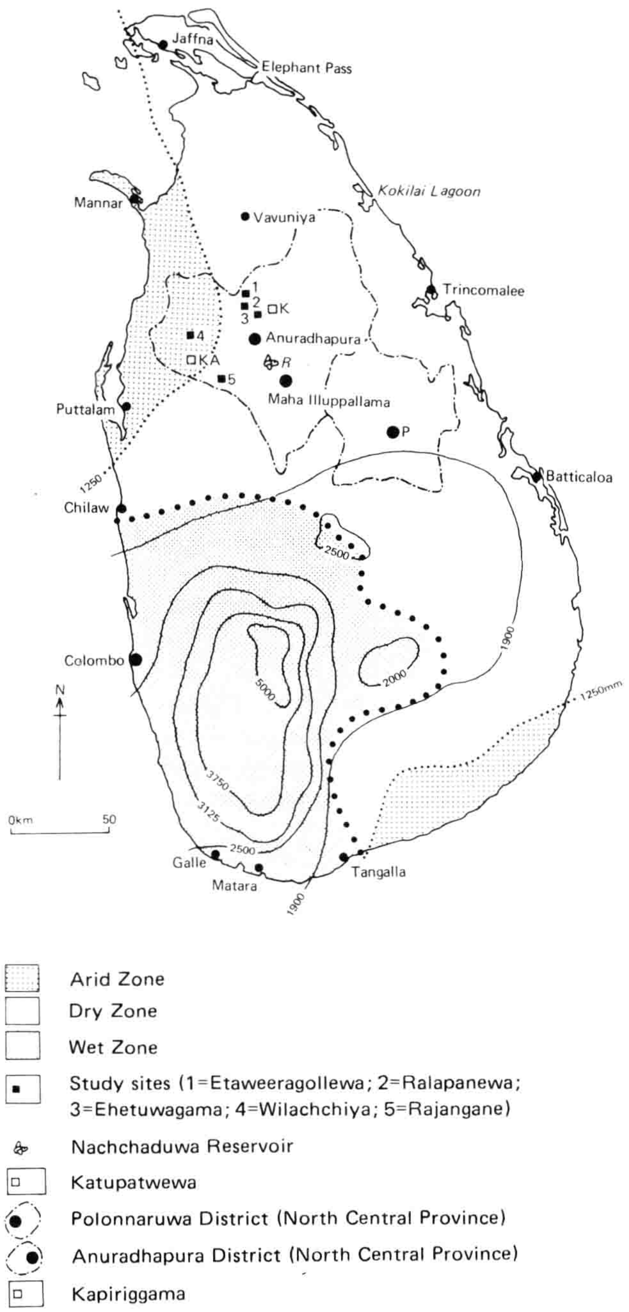

FIG. 2.1. Sri Lanka: Rainfall Zones and Study Sites

Note: Annual rainfall isohyets are indicated in mm.

they have come to be generally regarded together as the Dry Zone of Sri Lanka, occupying more than two-thirds of the island. Thus, the boundary between the Arid Zone and the Dry Zone proper has not been considered an important boundary in the past.[2]

The boundary to which the greatest importance is attached is the 1,900 mm average annual isohyet separating the Dry Zone which is predominantly subsistence agricultural from the Wet Zone which is dominated by plantation agriculture.

Though the validity of using the 1,900 mm average annual rainfall line as the boundary between the Wet Zone and the Dry Zone has been questioned from time to time, this line was accepted as the suitable boundary for the purpose of this study because of its agricultural significance.[3]

Topography, Drainage, Irrigation, and Soils of the Dry Zone

From the Central Highlands of the island, a series of mountain ranges stretches out fan-wise towards the north-western, northern, and northeastern coasts. In the Dry Zone, immediately below the 300-metre contour, the landscape could be well described as ridge-and-valley topography. Here, the ridges are mainly high and broad; the valleys are narrow and have relatively steep slopes. This topography provides ideal dam sites for the construction of deep tanks (reservoirs) to store water for irrigation, but it restricts flat lands required for inundated paddy cultivation. Hence, there is generally a low density of tanks in that girdle of land immediately below the 300-metre contour. Though the tanks in this area are deep they are highly susceptible to gradual but constant sedimentation because of their relatively steep catchment areas.[4] Haphazard clearing of vegetation in the upper recesses of the ridge for garden or *chena* (shifting) cultivation often accelerates sheet erosion on the slopes and silting of the tanks below.

Beyond this belt of prominent ridge-and-valley topography, notably in the north central region,[5] the mountain ranges become narrow and highly dissected with broad shallow valleys transforming the ridge-and-valley topography into an undulating land. Near the northwestern, northern, and northeastern coasts the undulations in the topography become almost imperceptible.

The undulating topography provides ample sites for construction of medium- and small-size tanks, blocking the ephemeral rivulets. The broad open valleys in between, being very shallow, have almost imperceptible side slopes providing ample flat land for the development of levelled paddy fields and sufficient gradient to develop a distributory channel system to conduct water from the tanks to the fields. In the Anuradhapura District alone,

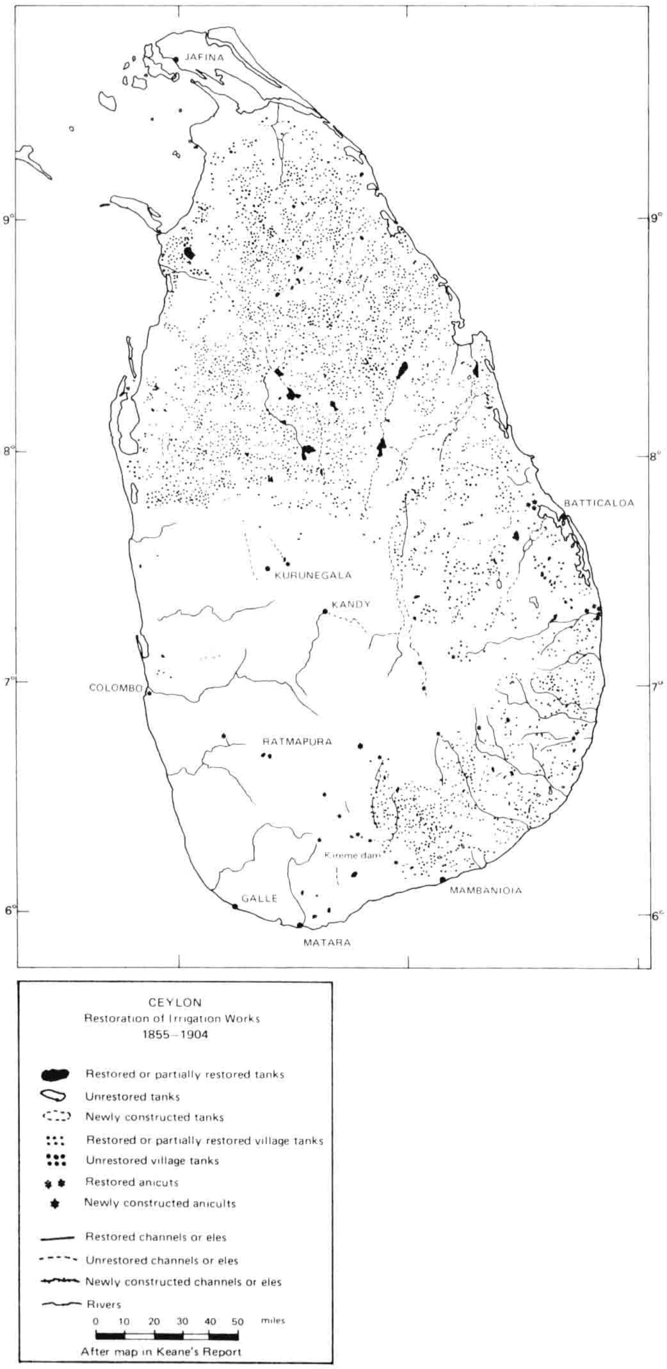

FIG. 2.2. Ceylon: Restoration of Irrigation Works, 1855–1904

Source: Sir John Keane, "Report on Irrigation in Ceylon," *Sessional Paper* no. XLV of 1905, Colombo: Govt. Printer, 1905.

there are over 3,000 tanks in an area of 7,752 km^2, or roughly one tank per 3 km^2. Some of the tanks are so small that they run completely dry if there is no rain for about two months (Tennakoon 1974). As can be seen in Fig. 2.2, the density of tanks is perhaps the highest in the Anuradhapura District.

Farther away from the Anuradhapura District, mostly towards the northwestern littoral belt on the Jaffna Peninsula, the density of tanks is reduced due to three main reasons:

1) Limitation of tank sites because the land is flat.
2) Poor stream run-off due to low rainfall and highly restricted seasonality of rainfall.
3) The rapid infiltration characteristics of the wide stretches of red-yellow latosol[6] soils in the northwestern littoral belt from Puttalam to Elephant Pass and in the northeastern littoral belt from Kokilai Lagoon to Elephant Pass.

The density of tanks is also low in that part of the Dry Zone lying to the east of the Central Highlands; in the immediate eastern slopes of the Central Highlands there is a very irregular relief with numerous inselberg formations, and farther away towards the eastern coast the land is very flat.

In that part of the country where the ridge-and-valley topography has given way to an undulating landscape, such as in the Anuradhapura District, where tanks have been developed by blocking the ephemeral rivulets in the valley bottoms, there is a distinct tank-field-tank pattern of land use. A stretch of paddy fields depending on a tank upstream merges into the storage area of the tank below. The tank is followed downstream by yet another stretch of paddy fields. So the process continues down a stream until the topography becomes too flat for tank construction. In the undulating topography the major ephemeral rivulets occupy the keels of the valleys. These major rivulets are joined by small and highly seasonal tributaries that rise in the side slopes of the ridges forming very roughly a dendritic pattern (Fig. 2.3). One or two small tanks and paddy fields occupy the keels of the valleys while the ridge crests and their immediate slopes are occupied by forests or patches of highland cultivation mostly in the forms of *chenas.*[7]

In the undulating landscape the tank beds and the paddy fields are mostly made up of alluvial soils (Moorman and Panabokke 1961). These alluvial soils vary from heavy clay to coarse sand in texture. The thickness of the alluvial soil layer varies from about 2 metres[8] in the tank beds to about a few centimetres in the marginal paddy lands in the lower slopes of the ridges. The alluvial surface soils gradually give way to the reddish brown earth which dominates most

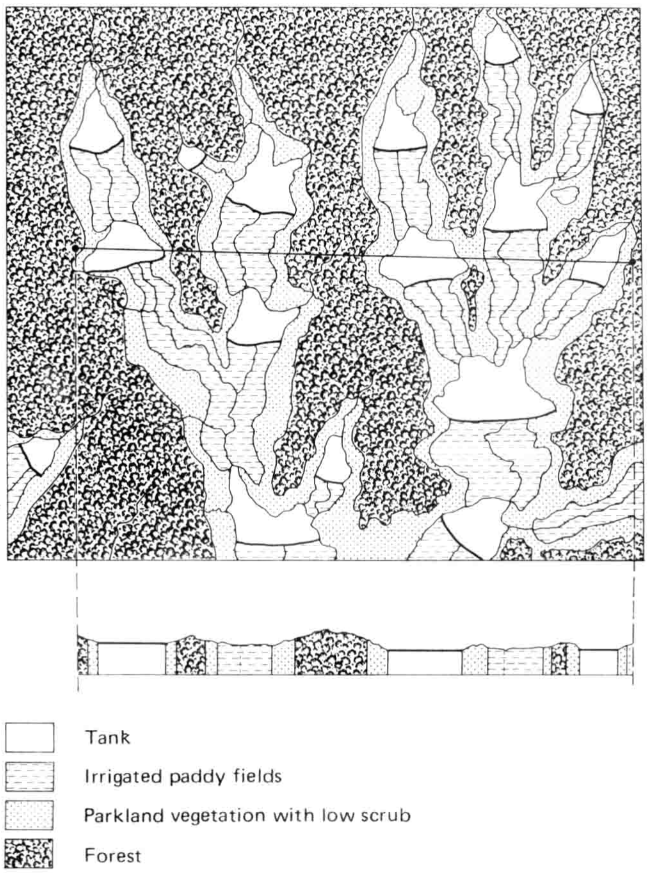

FIG. 2.3. Schematic Diagram of Typical Land Use Pattern in the Anuradhapura District

parts of the slopes of the ridges. Impoverished brushwood vegetation due to repeated forest clearing for *chena* cultivation is mostly confined to the reddish brown earth. This shows that the change in soil distribution had, at least in the past, a significant impact on the change in land use. As will be seen below, recent action in ignorance of this reality has led to many negative effects on the whole ecosystem.

The reddish brown earths occupy by far the largest part of the north central region. The A horizon of these soils usually varies from 250 mm to 125 mm in thickness and may become alkaline in their B and C horizons. Some of these soils developed from acid to highly basic (crystalline limestones) parent materials. As this soil is less favourable for flood irrigation, soil scientists warn that if it is necessary to expand flood irrigation further, it must be essentially restricted to the brown-coloured sub-groups of reddish brown earths, which are alluvial associates (Moorman and Panabokke 1961).

Most of the summits of the ridges in the undulating terrain are covered with quartz or iron-stone gravel, which in some places has erosional remnants of granite rocks. In the regions where the undulating landscape merges with the flat land in the northwestern and northeastern littoral belts, the red-yellow latosols cover almost the entire surface of land, leaving only the stream courses with alluvial deposits. Between the latosol soil region and the seacoast are the sandy alkali or saltish soils which are highly unsuitable for grain cultivation of any form (Government of Ceylon 1968).

Tank irrigation grew out of the necessity to store water and to regulate the supply of water required in inundated paddy cultivation, which is the basis of the subsistence economy in the Dry Zone, where the total annual rainfall is insufficient and too erratic for rice cultivation. The land use pattern which it fostered in the past was strictly in conformity with the topography and drainage pattern. The tank irrigation system, in minimizing the drought losses, also formed the basis of a unique hydraulic civilization. Yet, from time to time in the past, there have been serious droughts due to the combined effects of fluctuating rainfall and man's misuse of his environment.

Vagaries of Rainfall in the Dry Zone

The total annual rainfall in the Dry Zone, when compared with most arid regions in the world, is high (635–1,900 mm) but highly seasonal. The northeast monsoon is the chief source of rain for the Dry Zone and lasts from late October or early November to late December or early January. During these two to three months, most Dry Zone stations receive 45 per cent to 50 per cent of their total annual rainfall. The rainfall during the pre-northeast monsoon period, that is, in very late September or in October, is caused largely by cyclonic activities and provides another 20 per cent to 25 per cent of the average annual rainfall. Thus about 65 per cent to 75 per cent of the rainfall is concentrated into a period less than four months long (October to early January). Some heavy rains, however, do occur during late March and early April. The seasonality of rainfall is so marked that three to four months without any rain at all is common in years of normal rain, and in lean years, four to five months of such continuous drought is expected in the Arid Zone.

Fig. 2.4 shows seasonal and monthly variations of rainfall in Anuradhapura in the north central region of the Dry Zone. In 1951/52, the total rainfall received during the northeast monsoon period from October to January was 783 mm, and it declined to 487 mm during the same period of 1952/53. Similarly, the total rainfall of 881 mm in the October-January period of 1954/55 decreased almost by half to 440 mm during the same period of 1955/56.

Apart from the variability of seasonal rainfall from year to

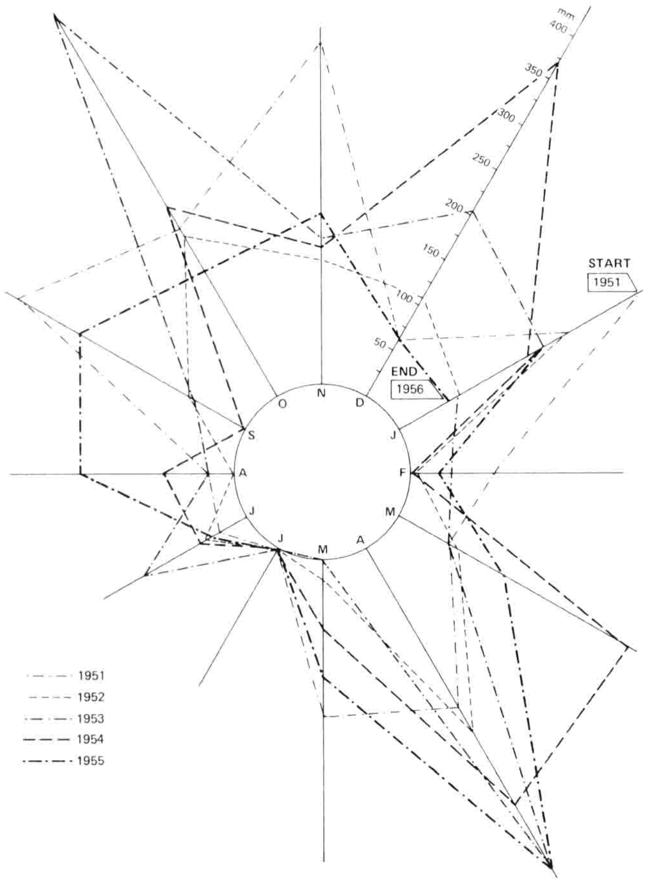

FIG. 2.4. Anuradhapura: Monthly Rainfall Fluctuation, 1951-55

Source: *Anuradhapura Monthly Rainfall Records 1951–60,* Department of Meteorology, Colombo.

Note: Monthly rainfall values are plotted sequentially from January 1951 to January 1956.

year, there are significant monthly variations within a single October-January season (Table 2.1)

During this period, notably from October to December, any month can bring the lowest and the highest rainfall of the season in a span of three or four years. Heaviest concentrations may occur in October followed by weak rains during the rest of the season, and the situation may reverse in the next season (compare 1953/54 with 1954/55). Furthermore, as happened in 1951/52, the weak October rains develop into very heavy rain storms in November which are followed by extremely poor rains in December. Because of the high variability of seasonal rain experienced in the Dry Zone, if a reasonably high amount of rain is not received in October, the chance of receiving adequate rain remains an uncertainty until the tail end of the northeast monsoon is reached in early January of the following year.

Like the total seasonal rainfall, the total annual rainfall varies very widely. During the period 1931–60, it varied from 736 mm to 1,777 mm in Anuradhapura City; this is not far from the conventional boundary of 1,250 mm[9] that separates the Arid Zone from the Dry Zone proper (Fig. 2.1). Added to the high variability is the periodical failure of rainfall. Very roughly, every 20 years there have been major droughts following two or three successive northeast monsoon failures. Thus, in the north central region of the Dry Zone there were major droughts in the periods 1933–35, 1954-56, and 1973-76. The 1954-56 drought was nationally significant because it affected almost the entire Dry Zone, while the 1973–76 drought was localized in the western half of the north central Dry Zone. Between these major droughts, several minor droughts occurred, but most of them went unobserved by the officials because of their highly localized nature. Generally, there is a drought once in every 4–5 years at a given locality. Such seasonal, annual,

TABLE 2.1. October-January Rainfall: Anuradhapura, 1951/52–1955/56

Year	October	November	(Rainfall in mm) December	January	Total October—January
1951/52	191	335	66	191	783
1952/53	180	122	114	71	487
1953/54	439	142	208	168	957
1954/55	216	135	378	152	881
1955/56	145	168	66	61	440

Source: Government of Ceylon, Department of Meteorology, *Anuradhapura Monthly Rainfall and Temperature Records,* 1951-1961 (unpublished), Department of Meteorology, Colombo.

and periodical rainfall variabilities show that rainfall in the Dry Zone is highly unpredictable.

In most parts of the tropical monsoon lands, high intensities of rainfall have been observed (Mohr 1944; Brookfield and Hart 1966; Jackson 1977). A fall of 25.4 mm in 20 minutes and another fall of 75 mm in 60 minutes in December 1951 as well as a rainfall of 25.4 mm in 8 minutes in December 1955 have been recorded in the Dry Zone Agricultural Research Station at Maha Illuppallama, near Anuradhapura (Farmer 1957). Because of these high intensities, in some years the bulk of the total annual rainfall occurs just within a few days. For instance, 598.7 mm out of a total of 1,354.6 mm of rain received at Anuradhapura in 1942 occurred within a few days of December that year. Similarly, more than one-third of the total annual rainfall of 1957 was received at the same station within three weeks of December of that year. The important thing here is not the high volume of rain but the intensity and potential damage of the precipitation in terms of surface soil compaction, restriction of percolation, and sheet erosion on steep gradients.

In addition to the problem of accentuated run-off and the resultant loss of rain water directly, there is an indirect but important source of water loss, namely, evapo-transpiration (Fig. 2.5). The average temperature in the Dry Zone does not fall below 27°C. As shown in Table 2.2, for at least four to five months of the year the day temperature reaches 32°C, resulting in extremely high evaporation, notably during the hottest months of March–April and June–August. In addition to the high temperatures there are the dry winds which sweep across the Dry Zone accelerating the evaporation, particularly during the rainless months from May to September.[10] During this period, streams as well as a majority of the tanks remain dry and parched.[11] It is only during the two rainy periods – from October to December and in April – that the total amount of moisture lost through evaporation is less than the total amount of

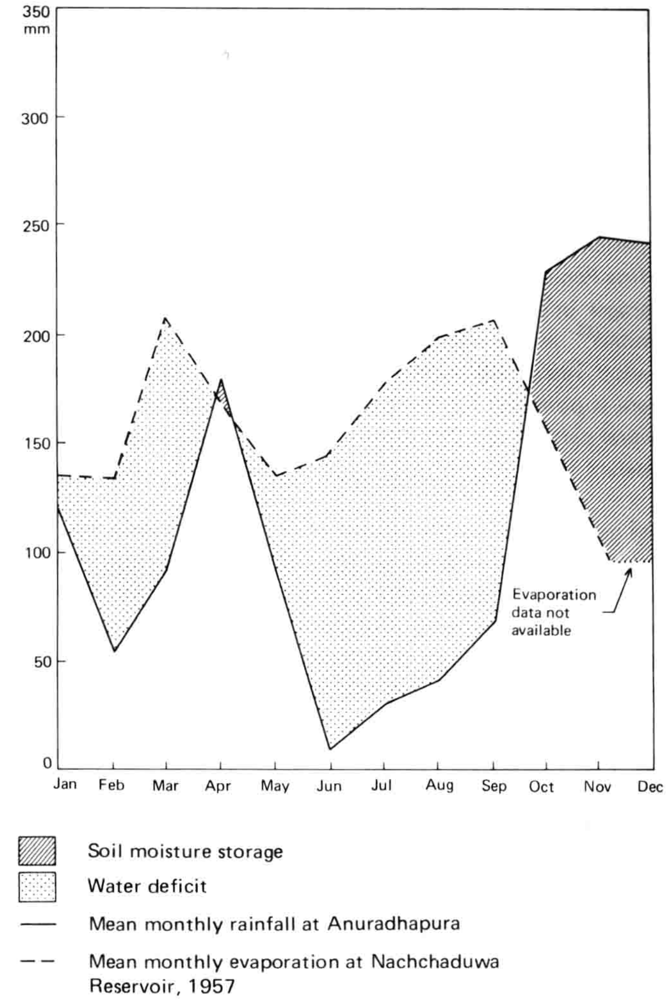

FIG. 2.5. Anuradhapura: Rainfall and Evaporation

Source: *Anuradhapura Monthly Rainfall Records* 1931–40, 1941-50, and 1951–60, Department of Meteorology, Colombo; Nachchaduwa Daily and Monthly Evaporation Record 1957, Hydrology Division, Department of Irrigation, Colombo.

TABLE 2.2. Mean Maximum Monthly Temperature, Anuradhapura, 1965

Month	Temp. °C	Month	Temp. °C
January	28.6	July	32.7
February	30.7	August	32.2
March	33.2	September	30.6
April	33.3	October	31.8
May	30.6	November	29.9
June	32.3	December	28.5

Source: Government of Ceylon, Department of Meteorology, *Report of the Colombo Observatory for 1965,* Department of Government Printing, Colombo, 1970, p.4.

rain received in the Dry Zone (Fig. 2.5). Thus, in years of rainfall failures during these two seasons, severe and prolonged moisture deficiencies are inevitable.

Recycling of groundwater is a measure successfully adopted in the Jaffna Peninsula to supplement the surface losses as well as the deficiencies of seasonal rainfall often experienced in agriculture and domestic use of water. The Jaffna Peninsula in the north has large underground water storages in its limestone bedrock. Such acquifers are limited[12] in the rest of the Dry Zone (Government of Ceylon 1969), although some scholars have argued that there is potential for the harnessing of groundwater in several parts of the Dry Zone (Fernando 1973; Madduma Bandara 1974).

The groundwater levels remain artificially high near the tanks and the ephemeral rivulets, but steadily decline with the drying up of these tanks and streams. In the Dry Zone, wells dug in the homestead gardens near the village tanks have higher water levels than those at some distance from the tanks, notably during the rainy seasons. With the advance of the dry seasons, the water levels decline steadily away from the tanks and wells often dry up completely. Finally, at the height of the drought, when the village tanks dry up, the water levels in those wells in the immediate neighbourhood decline steadily and sometimes run totally dry. In years of severe droughts even deepening of these wells down to the hard rock base and sometimes into the rock (often 6 to 10 metres and occasionally beyond) does not provide the minimum domestic water requirements of the community. The stress situation of water scarcity is such that people are then forced to open up temporary wells in the dry tank beds. Water shortage in one of the study sites – Etaweeragollewa – was so acute in 1976 that as many as 14 temporary wells were dug in the village tank bed. During the time of the field work in this village it was revealed that these wells could barely meet the domestic water requirements of about 400 people in 90 households and an estimated 300 cattle.[13] This amply demonstrates how scarce is water, which is the most valuable resource in the Dry Zone.

Man-made Problems in the Dry Zone

Irrigated paddy cultivation forms the backbone of the Dry Zone economy. Hitherto, it has been shown that both suitable land for irrigated paddy cultivation and irrigation water are highly limited in the Dry Zone. Terrain and soil characteristics limit the land suitable for irrigated paddy. Problems associated with insufficient rainfall and poor groundwater limit the irrigation water. Therefore, given that agricultural labour is adequately available for the successful cultivation of irrigated paddy water and suitable land are the other important but scarce inputs in the Dry Zone and must be used as economically as possible. Serious problems are bound to occur in misallocating one or both of these inputs in the course of development.

The Early Neglect of the Dry Zone

The ancient irrigation works testify that the economic importance of water had been fully identified in the past. Its successful use paved the way for the emergence of a highly developed hydraulic civilization in the Dry Zone (Gunawardane 1971). This civilization began to collapse[14] by about the thirteenth century (Roberts 1972), and the Dry Zone remained desolate until the beginning of the twentieth century.

However, the Dry Zone was not completely abandoned. A few settlers remained and eked out a living from limited patches of deteriorating paddy fields under poorly maintained tanks as well as from *chena* cultivation in the vast jungle that surrounded the villages. If a breached tank was irreparable it was abandoned and the villagers settled under a nearby tank in operation (Arumugam 1957). The dependence of a settlement on a tank was so great that it has been often said that a tank means a village and a village means a tank (Ievers 1899; Arumugam 1957; Tennakoon 1974). From the accounts of Robert Knox (1681) and Tennent (1859) it is clearly evident that those who remained in the Dry Zone had been reduced to a group of diseased and poverty-stricken peasants. A disease called *parangi* (yaws) and endemic malaria kept the mortality rate high (Roberts 1972).

During the first century of British administration of the island, no significant effort was made[15] to develop the Dry Zone, even though the need to develop it had been voiced by some British officials in the island from time to time (Horton 1833; Bennet 1843; Tennent 1859; Skinner 1891). In fact, the rigid land policy that the British adopted[16] was detrimental to the development of the Dry Zone (Farm 1957; Roberts 1972; Tennakoon 1972).

The neglect of the Dry Zone during the early British administration can be well seen in the demographic characteristics of the late nineteenth and early twentieth centuries. As can be seen in Table 2.3, the population of 6,031 in the Polonnaruwa District in 1891 has fallen to 5,808 in 1901. There is a similar drop in population in the same district from 1921 to 1931. In the North Central Province the population density of 6 persons per km^2 in 1871 increased to 9 persons per km^2 only after 60 years in 1931.

Redevelopment Efforts in the Dry Zone

From the time of World War I it became necessary to redevelop the Dry Zone for several reasons:

TABLE 2.3. Population of the North Central Province (Anuradhapura and Polonnaruwa Districts), 1871-1931

Administrative Division	Census Year						
	1871	1881	1891	1901	1911	1921	1931
Anuradhapura District	58,000 (7)	61,049 (8)	69,302 (9)	73,302 (9)	79,498 (10)	88,289 (11)	89,454 (11)
Polonnaruwa District	4,779 (1)	5,119 (1)	6,031 (2)	5,808 (1)	6,778 (2)	8,236 (2)	7,907 (2)
North Central Province	62,779 (6)	66,168 (6)	75,333 (7)	79,110 (7)	86,276 (8)	96,525 (8)	97,361 (9)

Source: *Census of the Island of Ceylon 1871,* Vol. 1 (Colombo: Government Printer 1873) and L. J. D. Turner, *Report of the Census of Ceylon 1931,* Vol. 1 (Colombo: Statistical Office 1931). Also see B. H. Farmer, *Pioneer Peasant Colonization in Ceylon,* London: Oxford Press 1957.

Note: Population per km^2 in parentheses.

1) Though the population in the Dry Zone declined during the early British administration, there was a rapid increase of population in the Wet Zone as the British made a concerted effort to develop plantation agriculture, while food production in the Dry Zone did not progress due to its neglect.
2) Increasing food prices and irregularities in shipping during World War I strained the balance of trade of the island's economy and also threatened the regularity of food supplies.
3) There was an urgent need to establish new settlements to relieve the mounting population pressure in the Wet Zone.

These led to two major developments in the Dry Zone. First were the village expansion programmes introduced to the existing villages, notably under the Land Commission of 1927; peasants were allowed to purchase or lease lands suitable for irrigated paddy cultivation or highlands in extents varying from 1 to 5 acres (0.4-2.0 ha) so that production could be increased as quickly as possible. Second was the establishment of government-aided peasant colonization schemes in the Dry Zone,[17] mostly to encourage the migration of the landless people of the Wet Zone.

During the early phase of the colonization schemes the progress was extremely slow. Therefore, it was necessary to offer more and more incentives to attract the colonists from the Wet Zone to settle in the Dry Zone. In addition to the provision of a developed 5-acre (2.0 ha) block of irrigated paddy, 2 to 3 acres (0.8-1.2 ha) of highland with a "type-plan" (standard) cottage and irrigation water free of charge as well as financial assistance to purchase basic materials were provided by the state to the selected settlers (Farmer 1957; Tennakoon 1972). However, by about 1950, the peasant colonization became such a success that it increased the demand for land in the Dry Zone and motivated the landless peasants in the Wet Zone to move on their own into the Dry Zone. By 1953 there were about 90,000 colonists in the Dry Zone (Farmer 1957) and there were over 5,000 squatters, labourers, and boutique keepers who were largely dependent on the colonies. In the 1960s the demand for land in colonization schemes became so high that the 5-acre irrigated paddy allotments of the 1940s had to be reduced to 2-acre allotments to provide lands for the increasing number of applicants.

By the end of the 1940s there emerged two distinct types of rural settlements in the Dry Zone — the traditional rural settlements often known as the *purana* (old) villages[18] and the peasant colonization schemes.

During the last two decades these settlements have grown in population and have brought marginal lands under cultivation. The opening up of new lands for irrigated agriculture was highly restricted by law in the colonization schemes but not in the villages. In fact village expansion was an avowed policy of the government. The policy of expansion of cultivated lands undoubtedly has improved the living conditions of the peasants and contributed in some measure towards the domestic food production. However, on the negative side is the mismanagement of available land and water in the Dry Zone. How both these resources are