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Problem of Desertification in Arid Zone of Rajasthan – A View

R P Dhir
Central Arid Zone Research Institute, Jodhpur – 342 003 India

Abstract Though vicissicitudes have occurred in the past, the climate with its assemblage of good and bad years is believed to have remianed steady from the historic period upto the present. The dominant sandy soils have high basic erodibility but are conservative of moisture and fertile enough to support a vegetation cover as is permitted by the rainfall regime. The natural vegetation is diverse, well adapted, largely palatable and efficient builder of biomass. Therefore while granting an ecological fragility to the area, the natural endowments are not the root cause for all the degradation taking place in the arid region of western Rajasthan. The tract has a long history of human settlement and landuse but the past six-seven decades, have witnessed a vast expansion of crop-based landuse. This has occurred partly at the cost of the earlier fallow farming system but mainly by taking cultivation onto new lands including the dunes and the areas where climate is only marginally conducive to farming. The change is the direct outcome of the rising human population and man's increased competence. The situation has lead to a greatly increased incidence of wind erosion and generation of drift sands, including appearance of barchans. However, overall the land productivity losses are fortunately mild so far though other costs are considerable. A more serious consequence of man's intervention has been in the open pasturelands, where more than two thirds of the area is in a state of largely severe degradation. Decliining water table in good aquifers due to over exploittion is another alarming development.

Scientific research has given a set of technologies and likewise impressive strides have been made in development of irrigation, electrification, means of communication, drinking water supply and afforestation. However, application of technologies has been tardy and environmental content of development effort is meagre. The crying need is containment of biotic pressure, reverting of marginally suited lands to pastures and a scientifically sound management of resources.

Key words Desertification problem, Review of desertification, Deserttifidation and development.

The process of land degradation, the damaging effects of which are most serious in ecologically vulnerable tracts, has bothered makined for the past several centuries but the topic has come under sharp focus and acquired critical significance only recently. The reasons for this are partly due to the fact that the problem has acquired a virulence only during the past few decades as a result of greatly increased human population and its enhanced competence to affect the natural endowments and partly due to the growing societal awareness and concerns about the consequences of the continued degradation to long term well being of man and his environment. The Indian arid zone is no exception in this regard. The problems of the desert and amelioration of living conditions of the inhabitants has been an area of national priority for more than four decades. The issue of desertification received a renewed emphasis as a prelude to and a consequence of the UN Conference on Desertification, that was held in the year 1977. Since then the topic has figured prominently in serveral meetings and conferences. However, perceptions have varied. The present author has been persuing different facets of the genesis and manifestation of the desertification process. Part of what is presented here has appeared in print elsewhere and the present endeavour is a synthesis of the same with some new emphasis, which may be considered subjective by others.

Natural endowments

Origin of the desert and role of man, if any

Occurrence of a desertic tract in our subcontinent, gifted as it is with a strong monsoon circulation, is a climatic peculiarity. This, together with the existence of a highly developed Harappan culture and the succeeding proto-historic cultures which flourished in the northern part of the arid zone provoked many as regard the origin and evolution of aridity in the region. Krishnan (1952) believed that the present pattern of rainfall distribution in the country was established when the Himalyas rose high emough to become an effective obstruction and ushered in the monsoon regime, i.e., about thirty five million years ago. He also opined that the general lowering of temperature during the ice ages and the presence of a fore-deep that was fed by the HImalayan rivers might have kept Rajasthan moist till sub recent times. Wadia (1960) associated the aridity with the postglacial period which started eighteen thousand years ago (18 ka BP). Ghose (1965), from a study in the central Luni basin showed that the region possessed an integrated drainage net work in the past, but the system was subsequently disorganised due to aridity. From Ghose *et al.* (1979) it is seen that the *Rig Veda* (c. 5 ka BP) mentioned the Saraswati as the mightiest river and that the same river became a dying river during the *Mahabharata* times (c. 3 ka BP). These authors and Kar (1993) reconstructed the former courses of the Saraswati and its tributaries including the Sutlej and showed that the decadence of this once mighty system was mainly due to a recent increase in aridity though neotectonism has played a role also. Roy and Pandey (1971) attributed the collapse of the Sarawati river system and associated riverine cultures to shifting away of its major tributaries, a process not uncommon historically. Misra (1985), based on the distribution of cultural sites in the region showed that the present Sutlej and the Yamuna were indeed flowing into the Sarawati then and discounted aridity as the cause of the shift.

Recently, a number of studies were carried out on the evolutionary hishtory of the desert. Singh *et al.* (1974) and Wasson *et al.* (1984) based on lacustral sequences showed that the period between 4 and 10 ka BP enjoyed substantially more rainfall than today. Allachin *et al.* (1978), while assigning considerable antiquity to aridity in the region, observed that the Middle Palaeolithic period (from c.25 to 45 ka BP) was characterised by wetter conditions, whereas the preceding and the succeeding periods were arid. They also showed that during these arid periods, the boundary of the desert extended well byond its present day eastern limit. It implies that the conditions then were even more arid than today. The data of Chawla *et al.* (1991) and Dhir *et al.* (1991 a) suggest that the major dunes present in the region were mainly formed during 17 to 11 ka BP. The latter authors, like Allchin *et al.* (1978), showed a number of cycles of aridity and climate amelioration, with the earliest evidence of aridity going back to 150 ka BP or so. Misra and Rajaguru (1989) found in a section through an obstacle dune, Acheulian stone age tool assemblage at the bottom and progressively younger cultural evidences, i.e. Middle and Lower Palaeolithic, upwards.

Summing up, aridity in the region goes back to 200 ka BP at least, if not beyond, and that since then the region has witnesses periods which were wetter of drier than that of the present day climate. All these vicissitudes were parts of a regional or global pattern. Man was only a mute witness to and not an actor in it.

Climate during the period of instrumented record

A fine resolution climatic record of the recent past is non- existent. Although it is believed that at the time of the invasion of Alexander in early 4th centuary BC, the region was not as arid as in the latter period, the chronicles for the period of Mahmud of Gazni (early eleventh century AD) mention that the journey of his forces from Multan to Somnath required elaborate arrangement for water, suggesting thereby that conditions then were not much different from that of today (Nazim 1931). A reliable record of rainfall in the region is available for over hundered years now. Singh *et al.* (1992a) analysed the 114 years (1871-1984) data on the monsoon period rains at 212 stations in north India, spanning Rajasthan in the west and Nagaland in the east. It included 27 stations of the arid zone also. Performance of various statistical tests between the mean values of two equal subperiods did not suggest any trend in rainfall amount. However, the 31 years running mean showed a tendency towards increased rainfall in the western half of the country, including Rajasthan and Madhya Pradesh and a decrease in the eastern part. Probably, if the period from 1985 onwards, which was marked by a series of drought years in the west is included also, this trend may level off. Thus it seems fair enough to conclude that the monsoon rainfall over the arid area if not increased, has not decreased for the instrumental record period. However, there are always short term fluctuations over the years, with occasional flood years and a number of sub-normal years. Between 1901 and 1987, the decades 1901-1910, 1911-1920 and 1961-1970 recorded the highest frequency of moderate to severe meteorological droughts in arid Rajasthan (Ramakrishna 1993). From 1984 the region experienced consecutive drought for four years. But all this is part of the climate cycle. Therefore, change in rainfall is not a factor to explain the dessrtification trends in the tract.

Soils and vegetation :

Nearly three fourth of the tract is made up of sandy soils, much of it in the form of dunes and hummocks. The sandy texture lies at one extreme of the textural range of soils and this endows the soils with low water retention capacity (50-115 cm per meter depth), high inflitration rate (5 to 20 cmh^{-1}), very low unsaturated state of hydraulic conductivity (8.12×10^{-8} cm day^{-1} as against 1.67×10^{-5} cm day^{-1} in sandy loam, both at 500 K Pa), an almost total lack of structure development and very high erodibility. The soils are also known for their low nutrient diffusivity and buffering capacities. The contents of the potentially available forms of major and micro nutrients are also less. For example, in the case of potassium, the potentially available form constitutes only half to one thrid of that in medium and fine textured soils (Dhir *et al*. 1991 b). The same is true for iron (Joshi *et al.* 1981), manganese (Joshi *et al*. 1982) and other elements. As regards available form of various nutrient elements and organic carbon, data in Table 1 show that organic carbon content of sandy soils is less than half of that in loams and clay loam soils. But difference in phosphorus, potassium and micronutrient contents is much smaller.

In light of above, it will be interesting to analyse the behaviour of sandy soils as a medium for rainfed cultivated crops and perennial vegetation. Though the stand of crops is somewhat poor on sandy soils, the growth of plants is as good as on other soils, and tillering is better. Crops do suffer some yellowing after heavy showers possibly because of leaching of soil nitrates, but crops do recover in course of time to a large extent. But deficiency sysmptoms of phosphorus and other nutrient elements are conspicuous by their absence. The yield of pearl millet is only a shade poorer and that of moth been and cluster bean even better on these soils (Kolarkar & Dhir 1981). Thus it seems that though obtaining proper stand of crops and soil and fertilizer nitrogen managemet are more exacting on sandy soils, the ease of root proliferation is able to compensate to a good extent. The stand and growth of natural perennial vegetation is much better on sandy soils than on other soils in open grazzing and fallow lands. This is possibly due to extra ordinary ability of sandy soils to conserve infiltrated rainwater as shown by Gupta (1979) and others. An analysis of foliage of thirty five dominant tree, shrub and grass species showed adequate level of major and micro nutrient elements (Dhir *et al* .1984, Sharma *et al*. 1985). Thus it seems, even the sandy soils have adequate inherent fertility to support and maintain a healthy vegetative cover such as is permitted by rainfall.

The tract is known to have nearly 700 plant species (Bhandari 1988). The perennials among these are deep rooted and tenacious enough to withstand extended droughts. The grass species are generally prolific seeders, quick to respond to moisture input and also efficient builders of biomass (Saxena 1976). Most plant species are palatable and rich in organic and inorganic nutrients from animal requirement view point.

Summing up, whatever is happening in the desert in terms of desertification is not due to any inadequacy in soil (except erodibility of soil), or vegetation. The reason lies elsewhere.

Population growth and landuse

History of human settlement and population growth.

Since the vast arid expanse south of the Ghaggar is blank on the Chalcolithic and Iron age maps of India, it seems that human occupation of the region was thin and depended upon hunting and limited pastoralism. Historians are generally of the view that organised settlement in the region began in the 4th century BC, following Alexander's invasion (Sharma 1966). A number of tribes migrated from the fertile Indo-Gangetic plains into this environmentally hostile, but otherwise secure tract in response to waves of invasions from the west. The settlements increased and expanded and by the 6th or 7th century AD much of arid Rajasthan was not only settled, but also politically organised. Jaisalmer tract, the driest in the area, was being ruled by a Rajput clan in the 10th century. About the same times Bikaner had several pastoral settlements (Tod 1832).

However, population must have been very thin then. Authentic record on population growth is not available, but a comparison of Nainsi's house hold number in some villages for the period 1658- 1664 with the mean of census data for the years 1891, 1921 and 1941, indicates that the population had doubled in the intervenng 250 years (Dhir 1982). Tod put the population of Marwar State at around 2 million in 1820 (Tod 1832). It was almost the same a century later. Therefore, not only the population

Table 1 *Organic carbon and available nutrient content potassium (mean values) in soils*

Soil series	Org C (%)	P_2O_5 (Kg ha^{-1})	K_2O	Fe	Mn (ppm)	Zn	Cu
Sandy							
Dunes	0.05	13.8	142	6.3	5.7	0.5	0.4
Chirai	0.10	15.6	180	6.4	6.3	0.5	0.5
Kolu	0.09	17.3	190	6.7	7.1	0.6	0.4
Kumprawas	0.14	21.0	195	6.7	10.1	1.2	0.6
Molasar	0.12	16.6	189	10.7	14.9	0.9	0.7
Pal	0.17	18.4	210	5.9	11.8	0.8	0.6
Sandy loam							
Pipar	0.22	19.2	240	5.6	11.2	0.4	0.9
Panchroli	0.24	20.4	260	9.0	17.9	0.8	0.7
Parbatsar	0.15	22.0	176	11.1	22.1	1.2	0.8
Clay loam							
Gajsinghpura	0.20	11.0	273	8.8	18.4	0.7	0.9
Asop	0.31	11.0	337	8.3	8.6	0.7	0.8

Source : Organic carbon and major nutrients – Dhir *et al.* 1991; Micronutrients – Sharma *et al.* 1985.

was thin, its growth rate was also small. However, from the year 1921 a phenomenal increase took place. The population more than doubled during the forty year period between 1921 and 1961 and redoubled in less than thirty years thereafter. The population growth rate for 1971-1981 and 1981-1991 were 36.6% and 30.1%, respectively, which are appreciably higher than that for the country as a whole.

Changes in land use

Some cropping was practised even by the early settlers in the region. The find of a huge jar used for grain storage of the Gupta period (AD 350-500) near Jodhpur is an evidence of it. During the Mughal period the Merta *Pargana* was earning revenue from both rainy and winter season crops, including cotton, sugarcane, vegetables and opium (Bhadani 1980). The same tract is known to have had as many 6500 irrigation wells then. Though agro ecologically better placed tracts as above had a well settled and prosperous agriculture, this activity in the rest of the area was much less. Dhir (1982) has shown that incidence of agricultural holding duirng Late Mediaevel times was only about one fifth of today. The process of rapid expansion of agriculture started with the rise of population. By the year 1951 much of the agriculturally usable lands in the climatically favourable tract from Sikar-Jhunjhunu in the north east to Jalore in the south was brought under the plough (Dhir 1982). However, the predominant system then was fallow farming, particularly in Churu, Jalore and Jodhpur districts. The trend since then has been intensification of farming in the already established agricultural tracts and breaking of new lands in the climatically marginally suited parts of Barmer, Bikaner and Ganganagar districts. In Ganganagar the contribution of expanding irrigation net work is there also to this observed trend. Even the driest district of Jaisalmer showed an increase in net sown area from 11,000 ha in 1951-52 to 2,34,000 ha in 1987-88 in The present landuse is given Fig.1.

Incidence of irrigation has also made impressive strides during the post independence era. The net irrigated area has increased from little less than 0.6 million hectare in 1955-56 to over 1.4 million by the year 1987-88.

The region has also witnessed a continuous rise in the livestock population, particularly of sheep and buffaloe, from the year 1956 to 1983. However, a series of drought years which followed since then

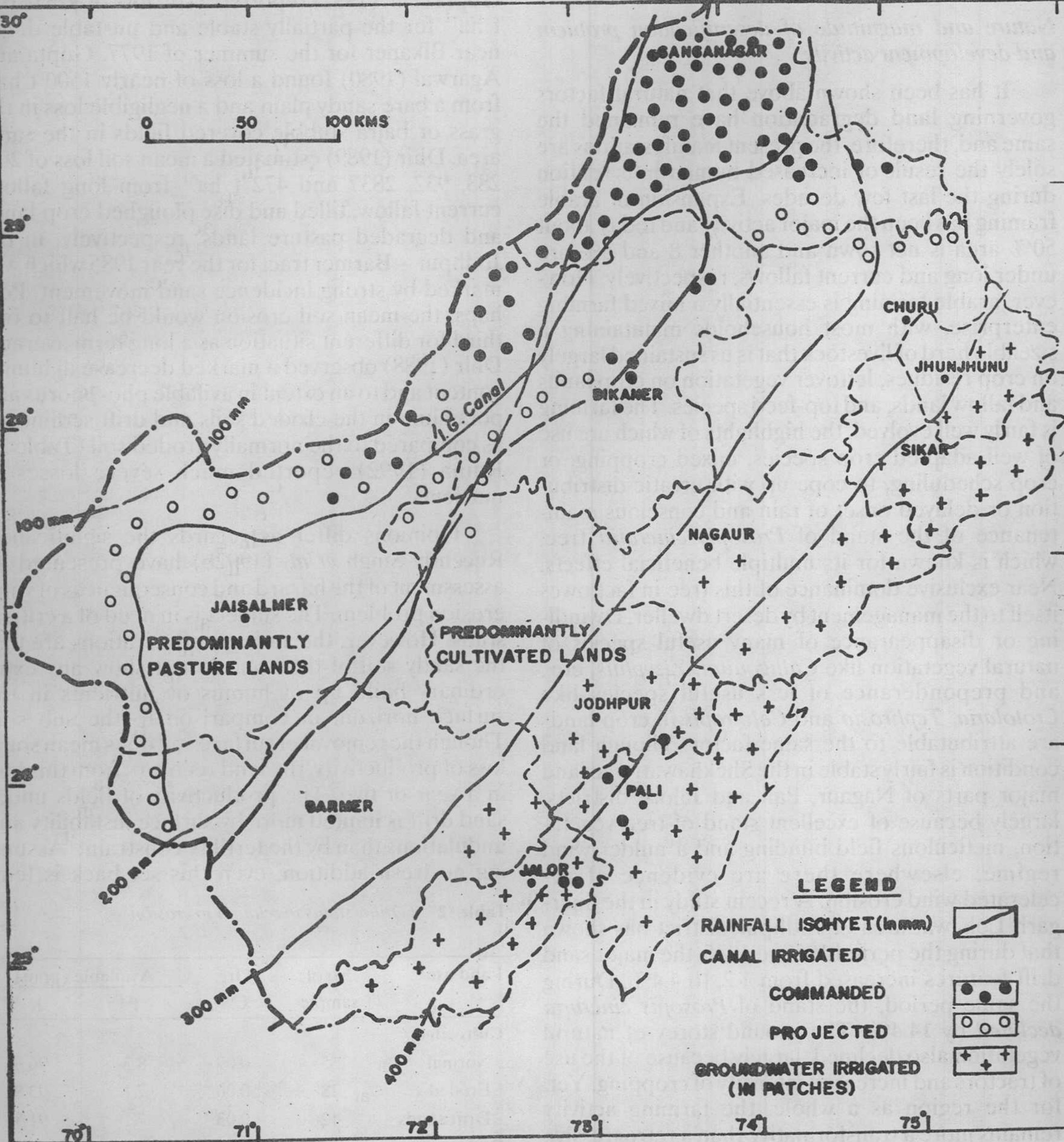

Fig 1 Present land situation in arid zone of Rajasthan. The bold dashed line separates the predominantly cultivated region from the mainly pastureland tract.

reduced the population to the level of mid seventies as revealed by the 1988 census.

Desrtification problems

Nature and magnitude of desertification problem and development activity.

It has been shown above that natural factors governing land degradation have remained the same and, therefore, the present manifestations are solely the result of increased human intervention during the last few decades. Expansion of arable framing has been the major activity and today about 50% area is net sown and another 8 and 5% are under long and current fallows, respectively. However, arable farming is essentially a mixed farming enterprise, with most households maintaining a sizeable herd of livestock that is us sustained largely on crop residues, leftover vegetation on crop lands and fallow lands, and top-feed species. The farming is fairly well evolved, the highlights of which are use of well adapted crop species, mixed cropping, or crop scheduling, to cope up with erratic distribution or delayed onset of rain and conscious maintenance of the stand of *Prosopis cineraria* tree, which is known for its multiple beneficial effects. Near exclusive dominance of this tree in fact owes itself to the management by desert dweller. Dwindling or disappearance of many useful species of natural vegetation like *Calligonum, Zizyphus*, etc., and preponderance of less useful species like *Crotolaria, Tephrosia* and *Calotropis* in crop lands are attributable to the same factor. Though land condition is fairly stable in the Shekhawati tract and major parts of Nagaur, Pali and Jalore districts, largely because of excellent stand of tree vegetation, meticulous field bunding and a milder wind regime, elsewhere there are evidence of accelerated wind erosion. A recent study in the Shergarh-Lohawat area of Jodhpur district has shown that during the period 1958 to 1985, the major sand drift features increased from 1.2. to 4.4%. During the same period, the stand of *Prosopis cineraria declined* by 14.4%. The ground storey of natural vegetation also declined, largely because of the use of tractors and increased intensity of cropping. Yet, for the region as a whole, the farming activity remains more a transformative than a retrogressive change.

Problem of wind erosion and sand drifts

The lower silt and clay content in the plough layer, as compared to that in the sub-soil of the sandy soils suggests widespread incidence of wind erosion in the region. Piles of drift sand and barchans are the more glaring manifestations of the same process (Fig. 2). The problem is common to both the arable farming and pasture landuses. Gupta *et al.* (1981) reported a soil loss of 325 to 615 t ha^{-1} for the partially stable and unstable dunes near Bikaner for the summer of 1977. Gupta and Agarwal (1980) found a loss of nearly 1500 t ha^{-1} from a bare sandy plain and a negligible loss in the grass or bajra stubble covered fields in the same area. Dhir (1989) estimated a mean soil loss of 207, 283, 932, 2837 and 472 t ha^{-1} from long fallow, current fallow, tilled and disc ploughed crop lands and degraded pasture lands, respectively, in the Jodhpur – Barmer tract for the year 1985 which was marked by strong incidence sand movement. Perhaps, the mean soil erosion would be half to one third for different situation as a long term average. Dhir (1988) observed a marked decrease in humus content and to an extent in avilable phosphorus and potassium in the eroded soils and drift sediments, as compared to the normally eroded soil (Table 2). Raina (1992) reported much severe losses of nutrients.

Opinions differ as regards the significance. Recently Singh *et al.* (1992b) have presented an assessment of the hazard and consequences of wind erosion problem. The subject is in need of a critical study. However, the author's observations are that the sandy soil of the area do not show any extra ordinary build up of humus or nutrients in the surface horizon, in comparison to the sub soil. Though the removal of surface soil does mean some loss of productivity, the land recovers from this loss in a year or two. The productivity of fields under sand drift is limited more by surface instability and undulations than by the fertility constraint. Assuming no fresh addition, even this set back is tem-

Table 2 *Fertility status in relation to erosion*

Land use	No of sample	Org. C%	Available (ppm) P	Available (ppm) K
Cultivated				
Normal	35	0.09	8.3	96.0
Eroded	18	0.06	7.1	93.8
Drift sands	12	0.03	7.1	91.5
Pasture				
Undegraded	7	0.12	8.7	108.0
Degraded	11	0.07	8.2	92.8
Drift sand	7	0.03	6.9	83.5

Source : Dhir 1989

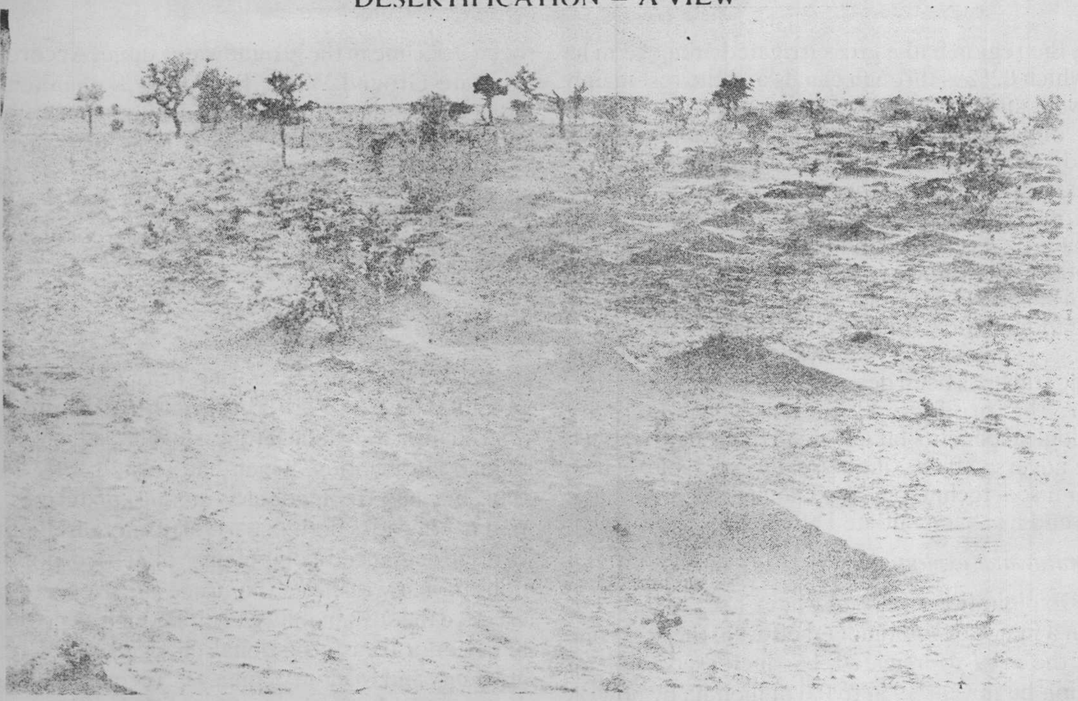

Fig 2 Accelerated wind erosion and generation of drift sands is a widespread phenomenon on farmlands. Though the adverse consequence on land productivity is still mild, other costs are considerable.

porary and the land recovers within a period of few years. The author believes that the current level of wind erosion should be a cause of 10-20% loss in crop production, as compared to a conservative farming. This thinking finds support also from data on crop productivity trends. For the principal crop of the tract namely, pearl millet, Gupta *et al.* (1992) have shown a negative compound growth rate of 1.95 and 0.53% per annum in yield for the more arid and less arid districts respectively for the period 1967 to 1987. Even this decrease may not entirely be consequence of erosion, as the cultivation of this crop on climatically marginal lands and reduced fallow farming have their contribution also to the observed trend. Perhaps, the irritance value of the sand drift problem for desert dweller and the effort involved in upkeep of means of communication are of greater serious consequence.

Degradation of pasture lands

Gupta and Saxena (1971), Shankaranarayan (1977), and Shankar and Kumar (1987) have drawn attention to the widespread incidence of degrdation of pasture lands, which constitute about 26% of the geographic area of the region and lie mostly in the tract with mean annual rainfall of 250 mm and less. Both the loss of vegetation cover and adverse change in composition are the serious manifestation (Fig. 3). Dhir (1988) estaimated that nearly two third of these lands are in a state of severe degradation or are already desertified. This picture was for the early to mid eighties. Technogenic activities related to IGNP and a devastating exploitation has worsened the situation further since. Perhaps, grazable biomass production now is only one-half to one-third of that possible under rational management. The loss of vegetation cover lead to increased surface instability and to poor regeneration. Thus a vicious cycle is set in motion.

Stony gravelly lands

These lands constitute nearly 5% of the area. Before human intervention, these lands supported some stands of *Accacia senegal, Commiphora mukul, Capparis* and also a ground storey of low perennials and grasses. However, to-day these are almost barren and without soil and present a picture of total wilderness. Though removal of vegetation was easy, the rehabilitation is going to be a very exacting job. This is the outcome of adverse human activity on very fragile lands.

Irrigation and its consequences

Harnessing of surface and groundwaters has been the most impressive post-independence development in the region. As per 1987-88 statistics, the region had a gross irrigated area of 2 m ha of which 62% is through canals and the rest mainly by wells and tubewells. Irrigation has brought about not only stability but also a quantum jump in production. There are some side- effects. In some situations use of poor quality waters has limited the use potentiality of land. In the canal command, 0.2 m ha area has water table between 1.5 to 6 m and another 25.6 thousand hectare at less than 1.5 m from surface. The problem is primarily due to over irrigation, influx from Ghaggar depressions and sepage from canals. On many a platforms irrigation in the tract has been decried for its ill-effects. However, the productivity increase and ancilliary ecological benefits far outweigh the negative effect. The adverse effects, if not totally avoidable, can be minimised technologically. Some action towards this end has been initiated already.

Groundwater exploitation

Exploitation of groundwater for irrgation has been a major developmental effort in the arid zone and the area so irrigated, has increased from 0.2 million ha in year 1956 to 0.6 million ha by now. A variety of cash crops besides the field crops are being raised. However, over the years there has been a decline in the groundwater table. According to State Ground Water Board, 39% of potential zone is already seriously over drafted (dark zone) and 6% is marginally so (grey zone). The overdraft is maximum in tracts where water quality is good. The present draft is, therefore, not sustainable and its continuation is bound to have far reaching adverse consequences.

Epilogue

Natural factors operating in the region have not changed and, therefore, the present day degradational dynamism owes itself exclusively to human intervention, which had existed for a long time but has tremendously increased during the past 6-7 decades both due to vastly increased number and enhanced competency of settled population. In many respects the usage of resources has exceded the sustainability level. Though agriculture has been a transformational change arising from ingenuity and wisdom of man, the recent expansion onto marginal areas is retrogressive from long term productivity view point. The widespread wind erosion and sand drift problem is considered a mild

Fig 3 The degradation of open pasturelands, arising from exploitative use, is the most serious manifestation of desertifiction. The loss of vegetation cover enhances surface instability, which in turn retards regeneration. Thus a self-propogating mechanism

hazard to productivity, though sand encroachment on the settlments, irrigation infrastructure and means of communication are serious. greater consequence is the depletion of groundwater and degradation of open pasture lands in Jaisalmer, Barmer and Bikaner.

Development activity of the past has helped in expansion of irrigation and thereby increasing and, to an extent stabilising productivity. However, a time has now come to greatly restrict raising of high water requiring crops and adopt improved water management on lands irrgated from ground water source. Else acreage under irrigation based on grounds water shall have to be curtailed. Other spheres of activities like drinking water supply, digging of *nadis*, country roads have helped in alleviating suffering of the people but the ecological content of various schemes has been small. Coverage under desert afforestation, pature development, sand dune stabilisation has touched only a small fraction of the problem. Road-side plantation, though have a salubrious effect, has proved counterproductive in protection of means of communication. Tractorisation has a place in the arid zone for various reason, but deep ploughing in the dominant vulnerable tract not only works as focii of severe erosion but also badly affected the regeneration of useful trees and shrubs.

But for the newly developing commands, the human and animal pressure has exceeded its limit of sustainability. Therefore, all efforts are required to contain further build-up. The landuse is in need of some restructuring so as to take the lands below 275 mm rainfall isohyet or so out of cultivation and instead used for animal rearing and dairying after revegetatation with grasses and shrubs. Likewise, the existing degraded pasture lands be rehabilitated for which proven technology already exists. Since, overriding factor in production shall remain the rainfall, even the developed pasture lands shall not produce enough in years of drought. Therefore, besides fodder banks, the landuse in Stage II of IGNP may be restructured so as to make it a source for supply of green fodder and a saviour in periods of acute scarcity.

Presently, the region is a curous mix of desertification and development going hand-in-hand and tilting the balance in favour of amelioration calls for not only governmental support but also a massive collective concern and effort.

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