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THE SCARCITY-ORIENTED GROWTH PATTERN OF ARID AGRICULTURE

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The particular assumptions regarding the behaviour of population growth and the availability of natural resources were responsible for classical (Malthusian and Ricardian) prophecies regarding the progress of the economy towards stationary state. Viewed in the context of imminent growth of population pressure, they feared the emergence of scarcity of natural resources, particularly agricultural land, which in the absence of improved technology was supposed to bring into operation the secular law of diminishing returns. Thus the operation of the law of increasing natural resource scarcity was fundamental to the classical theory of growth. However the modern technology (not foreseen by them) has considerably mitigated the potential scarcity of natural resources and has, therefore, dispelled most of the classical fears.¹

But in the context of Arid Zone of Western Rajasthan, some variant of classical thinking about the long run availability of natural resources may still hold true.² Here in the background of arid environment some economic and demographic forces as reflected in the prevailing pattern of growth of agriculture,³ appear to have given rise to the operation of law of increasing natural resource scarcity. This paper refers to some of the manifestations of the reduced physical availability of the natural resources.

The aforesaid phenomenon can be properly understood, once we recognize that the growth potentialities of agriculture in any region have direct bearing on the land—broadly representing the agriculturally relevant natural factor endowment. In other words, the ecological determinants, including soil-climate complex, set the limits to the physical production possibilities in agriculture. The optimum results from the land can be expected only when it is used just according to its ecological requirements. Failing this, the development efforts may prove self-defeating in the long run. This is so because by using land against its ecological requirements, the delicate ecological equilibrium—as influenced by soil structure, water movements, micro-organismic activity and the plant and animal nutrition—gets disturbed. Once disturbed, it may get settled at a lower level,

1. For a detailed study in this context see Harold J. Barnett and Chandler Morse : Scarcity and Growth: The Economics of Natural Resource Availability, Resources For Future, Inc., Washington, D. C., John Hopkins Press, Baltimore, 1963.

2. The situation in the context of arid agriculture is somewhat different from classical model, because in the latter case, they postulate a static ceiling on land of uniform quality in Malthusian case and, of graded quality in Ricardian case which however does not imply loss of the land resources. As against this, the emergence of scarcity of natural resources in Arid Zone implies loss of the land resources by way of their depletion resulting from their utilization beyond their use capabilities.

3. The term 'growth' has been used in the sense of its 'structural aspect.' The changing structure of arid agriculture, particularly changing pattern of land use, has been taken as synonym with agricultural growth.

thereby indicating still lesser production possibilities.⁴ And this is what appears to have happened in the Arid Zone of Western Rajasthan. That is why the Rajasthan desert is sometimes called the man-made desert.⁵

The Arid Zone of Western Rajasthan

The Arid Zone of Western Rajasthan, a part of Thar desert spread over an area of 2,14,039 sq. kms., constitutes about three-fifth of the Rajasthan State, and is separated from the eastern part of the State by the Aravalli hill. It comprises of administrative divisions of Jodhpur, Bikaner and part of Jaipur (*i.e.*, Jhunjhunu and Sikar districts). The region is mere desert in the far-west (Barmer, Jaisalmer and Bikaner districts), but it improves as we proceed towards south-east.

Climatically, the region is characterized by low and erratic rainfall (ranging from 5" to 20" per annum), extremes of temperature (20°C. mean maximum during winter and 50°C. mean maximum in summer), low atmospheric humidity and desiccating winds.

The soils of the region have been broadly classified as desert soils, which are mechanically disintegrated, immature, structureless, very coarse in texture, containing high percentage of soluble salts and having very low nutrient status. Because of their peculiar physical properties, the soils are highly subject to erosion hazard, when deprived of sufficient plant cover. Besides, commonly prevalent problems of salinity, alkalinity and poor fertility further reduce their productivity. The moisture deficiency limits the scope for any improvements through artificial measures.

The Use Capability of Arid Lands

The combination of paucity along with uncertainty of precipitation and deficiencies of soils, particularly their susceptibility to wind erosion, limits the uses to which the arid lands could be put. In the absence of superior technology, embodying the provision of irrigation and conservation-oriented land management in particular, no better use can be made of these lands except depending upon the spontaneous produce of the nature without in any manner aggravating the existing deficiencies of the natural resource base. The spontaneous produce of the nature in the Arid Zone is poor and sparse vegetation consisting of hard and drought-resistant trees, shrubs, perennial as well as annual grasses which can withstand the severity of arid environment.

By implication, then, the region is most suited to the pasture based system of livestock farming,⁶ which can rather thrive upon the deficiencies of the natural

4. Walter Firey: *Man, Mind and Lands: A Theory of Resource Use*, The Free Press, of Glencoe, Illinois, 1960, Chapter 2.

5. For detailed account see, C. S. Christian: *Report on Organisation of Central Arid Zone Research Institute, Rajasthan (India)*, UNESCO, South Asia Science Co-operation Office, New Delhi, 1959.

6. In this connection, see, for instance:

- (i) Report of the State Land Utilisation Committee, 1960, Government of Rajasthan, Government Press, Jodhpur, 1961.
- (ii) R. N. Kaul and D. K. Misra, "Land Utilisation Problem in Arid Zone and Its Significance in Soil Conservation," *Proceedings of the National Academy of Sciences, India, Section B*, Vol. XXXI, Part III, 1961.
- (iii) S. P. Seth and K. N. Mehta, "Fertility Survey and Soil Test Summaries of Some Districts of Arid Region of Rajasthan," *Annals of Arid Zone*, Vol. II, No. 1, 1963.
- (iv) *Techno-Economic Survey of Rajasthan*, National Council of Applied Economic Research, New Delhi, 1962, Chapter 2.

resource base, and can also conserve its economic life in the long run. Since it involves less intensive and less exploitative pattern of land use, the properly regulated system of livestock farming can make efficient utilization of land resources without disturbing the delicate ecological equilibrium of the nature.

THE PATTERN OF GROWTH OF ARID AGRICULTURE

In spite of the fact that natural factor endowment indicates greater growth potentialities in the livestock-oriented system of farming, the pattern of growth of agriculture in the Arid Zone reveals an entirely different picture. In the place of livestock farming based on regulated grazing, an exploitative system of mixed farming has been a general practice. Crop raising and livestock raising, both the components of the system, have led to ever increasing elimination of most needed plant cover, by way of clearing of the fields and over-grazing of the pastures. This has resulted in the utilization of the arid lands beyond their use capability.

These facts are supported by the land utilization records of different districts in the Arid Zone.⁷ Accordingly, 38.9 per cent of the total geographical area is under cultivation. If the fallow lands (current as well as 2 to 5 years old fallows) which, for all practical purposes, are broken to plough and devoid of permanent plant cover, are also considered, the total area cleared for permanent vegetation comes to 57.6 per cent. The same figure may rise to 69.5 per cent if we take it as a fraction of total geographical area excluding the areas put to non-agricultural uses, forests and barren waste lands where no ploughing is generally possible.

The extension of crop farming to such a large extent on the lands which are generally not suitable for cultivation, is apparently a symptom of over-exploitation of the land resources or rather it "amounts to mining them" as the State Land Utilisation Committee Report very aptly puts it.⁸

Similarly in the case of livestock raising, a comparison of availability of grazing resources and number of grazing animals suggests a state of serious over-stocking of the grazing space. According to 1961-62 figures, there were about 14.4 million heads of livestock in the Arid Zone. Of this, 36.3 per cent were sheep, 31.4 per cent cattle, 22.6 per cent goats and 9.7 per cent other animals such as camels, buffaloes, horses, donkeys, etc. When converted into standard cattle units, the total pressure of livestock amounted to 7.4 million cattle units. Viewed in the context of availability of natural pastures (including permanent pastures, uncultivable waste lands and culturable waste lands) there are about 99.9 cattle units per hundred hectares. However, the density of cattle units per hundred hectares is reduced to 67.5 when the fallow lands are also included in grazing lands. But

7. The data refer to the year 1961-62. It excludes the district of Ganganagar. Of the 12 districts of Western Rajasthan, Ganganagar has been excluded throughout in this paper in spite of the fact that it also has normal annual rainfall of only 300 mm. (<12"). The main reason for its exclusion is extensive irrigation facilities available to large part of this district because of which it does not portray the elements characteristic of the Arid Zone.

8. *Op. cit.*, p. 20.

looking at the 'poor range conditions' of the pastures, these figures far exceed their carrying capacity.⁹

As mentioned earlier, the utilization of arid lands beyond their use capabilities involves grave consequences in terms of increased scarcity of the natural resources. Before we discuss these consequences or indicators thereof, it will be proper to analyse the forces underlying this pattern of growth of arid agriculture.

FACTORS RESPONSIBLE FOR SCARCITY-ORIENTED GROWTH PATTERN

There may be many factors such as farmer's subsistence orientation, some sort of complementary relationship between crop raising and stock raising and occasionally tempting crop production possibilities, offered by the variabilities of the arid environment, which favour crop raising along with stock raising. However, the exploitative dimensions of the existing system of mixed farming can be explained in terms of imbalance between human and livestock population on the one hand and the availability of land resources on the other. The situation of imbalance will be quite apparent once we juxtapose the human and animal population growth with the changing land utilization pattern.

As noted earlier, the fulfilment of the dual objective of efficient current utilization and long run conservation of the resource base calls for an extensive pattern of land use. However, once the pressure on land mounts the former extensive land use pattern, implying lesser number of operators, small number of livestock and larger land holding per operating unit, becomes difficult. The increased intensity of land use at this stage is unavoidable. Precisely the same thing has happened in case of arid region of Western Rajasthan.¹⁰

Population Growth

The population of the Arid Zone (excluding Ganganagar district) was 6,959,262 persons according to 1961 Census, which has been rising ever since 1901 (except during the decade 1911-1921). During the last 60 years it has more than doubled, (e.g., has risen by 103.2 per cent). Table I gives the details about growth of population during the last six decades. The rate of growth of population was highest during the decade 1951-1961. During this decade, population has increased by 26.6 per cent.

9. Central Arid Zone Research Institute has been conducting various studies in this connection. Besides their Scientific Progress Reports, see R. B. Das, *et al.*, "Grazing Capacity Studies in Grasslands of Western Rajasthan," *Annals of Arid Zone*, Vol. II, No. 1, 1963; R. B. Das, *et al.*, "Studies on Rocky Range Land," *Journal of Soil and Water Conservation in India*, Vol. 13, Nos. 1 and 2, 1965.

10. The argument that pressure on land through encouraging the degree of intensity of land use may dynamize a hitherto stagnant agriculture does not hold true in case of Arid Zone, because here the increased intensity of and use devoid of any improvement in technology has only over-exploited the resource base.

For population pressure working as development agent see, Ester Boserup : *The Conditions of Agricultural Growth : The Economics of Agrarian Change under Population Pressure*, George Allen and Unwin, 1965.

TABLE I—GROWTH RATE OF POPULATION IN DIFFERENT CENSUS PERIODS IN THE ARID ZONE

Census period	Annual rate of increase (per cent)
1901-1911	0.95
1911-1921	—1.03
1921-1931	1.46
1931-1941	1.86
1941-1951	1.53
1951-1961	2.60

Source : Table adopted from A. B. Bose, "Population Trends in the Arid Zone of Rajasthan," *The Journal of Family Welfare*, Vol. XII, No. 3, March, 1966.

Changing Land Use Pattern

The trend in population growth has affected the degree of intensity of land use by way of putting more of sub-marginal lands under plough or increased intensive use of lands already under cultivation and intensive grazing of fastly shrinking pasture lands. In the absence of authentic data about land use and livestock covering the whole of arid region during the pre-independence era, the present argument has to be based on the records of the Revenue Department of the State since 1951-52.

The land use statistics during the decade 1951-52 to 1961-62 reveals the trend of putting the arid lands to move intensive use. As shown in Table II, not only the net area sown has increased by 49.5 per cent but the area under less intensive uses of land has considerably decreased, as revealed by the decline in fallow lands by 10.6 per cent, by the decline in culturable waste lands and uncultivable barren waste lands (generally used for grazing purposes) by 23.4 per cent and 26.1 per cent respectively.

TABLE II—LAND USE PATTERN IN ARID ZONE : 1951-52 AND 1961-62

Land use	Percentage of total geographical area		Per cent change during 1951-52 to 1961-62
	1951-52	1961-62	
1. Forest	0.8	0.9	+1.3
2. Miscellaneous tree crops	0.1	0.1	—6.6
3. Land put to non-agricultural use	4.8	2.8	—4.1
4. Barren unculturable (uncultivable) waste lands	18.1	13.4	—26.1
5. Culturable waste lands	28.1	21.3	—23.4
6. Permanent pastures and grazing lands	1.0	3.9	+76.9
7. Fallows other than current fallows	12.5	11.5	—7.9
8. Current fallows	8.5	7.2	—2.7
9. Net area sown	26.1	38.9	+49.5
10. Total cropped area	26.4	39.6	+50.8
11. Area sown more than once	0.3	0.7	+172.6
12. Irrigated area	1.0	1.7	+75.6

Source : Deputy Director of Revenues, Government of Rajasthan. The data have been suitably adapted according to requirements. It excludes Ganganagar district.

Pressure on Grazing Resources

While discussing the pressure on grazing resources as another factor responsible for over-exploitation of the natural resource base, it may be observed that during the decade 1951-52 to 1961-62, the shrinkage of pasture on the one hand and increasing population of livestock on the other, has resulted in serious overstocking and therefore over-grazing of pasture lands.

The overall grazing space including permanent pastures, culturable and uncultivable waste lands and the fallow lands has declined by 15.6 per cent (from about 13.09 million hectares to 11.04 million hectares) in the whole of the Arid Zone during 1951-52 to 1961-62. As against this decline in grazing space, the population of grazing animals has increased by 53.2 per cent (from 9.4 million to 14.4 million head of livestock) during the same period.¹¹ Consequently, the availability of grazing space per hundred cattle units has reduced from 256 hectares to 148 hectares. Viewed in the context of generally very poor carrying capacity of the pastures this suggests a grazing incidence of more than six times heavier than what the grazing lands can sustain.¹²

THE CONSEQUENCE: INCREASING SCARCITY OF NATURAL RESOURCES

The consequences of the situation described in the preceding pages manifest themselves in qualitative and quantitative deterioration in the overall availability of natural resources. In other words, the prevailing pattern of agricultural growth, resulting mainly from the pressure of population, has severely disturbed the ecological balance of nature in the Arid Zone. It is difficult to say precisely, to what extent aridity has been aggravated. However, some broad indicators of increased scarcity of natural resources are being presented below.

Soil Blowing and Dune Formation

The first and foremost consequence of the elimination of much needed plant cover by way of clearing of the fields and over-grazing has been the increased intensity of wind action. This has resulted in the removal of fertile top soil in some places and formation of hummocks and sand dune in others, thus reducing the availability of usable soil on both the accounts. Out of the total area of about 67,356 sq. kms. under sand dunes of different types and size in Western Rajasthan,¹³ larger part is covered by the 'new system' of sand dunes which is an outcome of unfettered biotic interference, e.g., removal of plant cover, over-grazing, intensive cultivation, etc.¹⁴ The dangerous designs of march of desert, especially blowing sands towards Uttar Pradesh and Punjab are now quite well-known.

11. The growth of some important categories of livestock is as follows : cattle 43.3 per cent, buffalo 30.9 per cent, sheep 62.6 per cent, goats 59.8 per cent and camels 74.6 per cent.

12. See studies by R. B. Das, *et al.*, *Op. cit.*

13. Taking the region as a whole nearly 58 per cent of the total area is partly or fully affected by sand dunes.

14. In this connection, see (i) Recent Development in Rajasthan, Chapter I—"Resources in Perspective" by P. C. Raheja and A.K. Sen, Souvenir Volume by the Ministry of Food and Agriculture, Government of India on the occasion of General Symposium on Problems of Indian Arid Zone-1964. (ii) A.K. Sen, "Some Geographical Features of the Rajasthan Desert," in General Symposium on 'Problems of Indian Arid Zone, 1964, pp. 606-617. (iii) S. Pandey, S. Singh and B. Ghosh, "Orientation, Distribution and Origin of Sand Dunes in the Central Luni Basin," in General Symposium on Problems of Indian Arid Zone, 1964, pp. 179-190.

Effects on Ground Water Supply

Being a complex geological phenomenon, it is difficult to make any categorical statement about ground water. However, it may be mentioned that in the upper catchment areas the removal of plant cover, causing excessive run-off and evaporation, formation of sand dunes, causing choking of the natural channels and artificial damming of the channels (as in case of Jawai dam) are most important factors affecting ground water supply. By adversely affecting the rate of 'recharge' they may lead to lowering of static water level or increased salinity of the water or complete drying of the wells. This phenomenon can be illustrated by large number of wells once in use, but presently dried up in the districts of Barmer, Jodhpur, Jalore, Nagaur and Pali.

Deterioration of Soils

The removal of plant cover has also contributed to the formation of patches of saline waste lands. Because of internal surface drainage the increased run-off due to removal of plant cover generally leads to impounding or stagnation of rain waters in some low lying areas, which, in the course of time, become saline waste lands.¹⁵

The quality of soil has further deteriorated by continued irrigation by saline waters. In the absence of flooding arrangements and other precautions, not more than one crop is raised on some lands in the districts of Jhunjhunu, Barmer, Nagaur, Jodhpur and Pali. In the past, it was the practice to raise two to three crops.

In some of the places in the newly canal irrigated area of Jawai dam, the salinity of soil has also come up with the rise in water table. This is one of the big problem of irrigation of arid lands where internal surface drainage prevails.

Deterioration of Vegetation

The scattered clusters of trees and their luxuriant growth in the old protected areas, technically called 'preservation plots' like 'Agors', 'Orans', 'Jods' and 'Birs' can give some idea of the production potentialities of the land. A comparison of these 'preservation plots' with the rest of the vegetation in different areas of Arid Zone may give an idea about the extent of depletion of forest resources. The increasing population of 'malformed trees' (i.e., bush like trees) is another indicator of the extent of deterioration. Speaking quantitatively, only 0.9 per cent of the total geographical area is under forests.

15. Sometimes the origin of natural salt lakes like Sambhar, Pachpadhara, Didwana, etc., is attributed to this phenomenon. In very recent times new saline depressions have been created in the lower reaches of seasonal streams. For instance, see, Scientific Progress Report of the Central Arid Zone Research Institute for the year 1965, p. 17. Also see, B. Ghosh, "Salt Basins in the Lower Luni Basin," in General Symposium on Problems of Indian Arid Zone, 1964, pp. 169-178.

In case of grass, the scarcity phenomenon is manifested by generally 'poor range conditions' of the pastures.¹⁶ The disappearance of high or superior perennials or even replacement of low perennials by annual grasses like '*Lapala*' and '*Bekaria*' and some non-edible weeds like '*Dhamasia*', '*Sinia*' and '*Jiwasia*' suggest a stage of ecological regression. They are clear indicators of deterioration in forage resources. Finally, the conversion of pastures near the village settlements or stock watering points into bare patches of soil further indicates the reduced physical availability of pasture resources.

The Increasing Stresses on Human Factor

In the ultimate analysis, the effect of all the scarcities is sustained by the human factor, who manages his precarious living out of such a fastly deteriorating natural resource base. His responses to the increasing scarcities are reflected in various farm practices. These could be looked upon as indicators of scarcity of natural resources vis-a-vis human and animal requirements.

The human reaction to increased scarcity of suitable soils for crop farming has taken three forms : (i) extension of crop farming to sub-marginal lands as exhibited by reduction in uncultivable waste lands and culturable waste lands (Table II); (ii) increased intensity of cultivation without much of improved technology as partly reflected by reduced extent of resting or fallowing of the land (Table II); (iii) increased intensity of cultivation with the aid of improved technology, such as conservation farming and additional irrigation facilities. During 1951-52 to 1961-62, the area under irrigation has increased by 75.6 per cent; however the total area irrigated was only 4.4 per cent of the net area sown during 1961-62.

Yet another form of human adaptation to land scarcity is seasonal out-migration of the people in search of earning towards the wet areas of the State and neighbouring States. This has also increased in some of the places.¹⁷

The reduced availability of the forage in the pastures is accommodated through (i) increased extent of supplementing grazing by partial stall feeding in case of settled population. The increased area under fodder crops (from 0.77 million hectares to 1.23 million hectares—60 per cent rise during 1951-52 to 1961-62) may be regarded as one of the rough indicators of supplementing the pasture forage by grown fodder; (ii) in case of nomadic or semi-nomadic stock raisers, the burden of increased forage scarcity is borne by the well watered areas in the neighbouring States of Punjab, Uttar Pradesh, Madhya Pradesh, Gujarat, and the eastern part of Rajasthan where they out-migrate and graze their animals free of charge,

16. Central Arid Zone Research Institute has classified the grass lands of Western Rajasthan into 'excellent', 'good', 'fair' and 'bad' range condition, depending upon their botanical composition, plant cover, etc. The 'poor range condition' describes a state of pasture where over 50 per cent of the plant stand consists of annual grasses, superior perennials are rarely visible. The plant cover will vary from 0 to 25 per cent in a 'poor condition range.'

17. Yet unpublished, information collected in connection of a study of 'Famine' by the author from some villages of Churu, Barmer, Jodhpur and Nagaur districts revealed that the extent of such casual out-migration is increasing.

when faced with scarcity conditions in the local territory. The increasing extent of pastoral nomadism is thus one of the indicators of increasing scarcity of grazing resources.¹⁸

In conclusion, it may be said that, left to itself, the present pattern of growth of agriculture in Arid Zone may lead to a permanent and irreparable loss of natural resource base. The only alternative to this, short of automatic creation of a menacing liability to the rest of the economy, is the introduction of resource conservation-oriented technology in the arid agriculture, thereby the productivity of arid lands could be increased in the short as well as in the long run.

18. The information collected by the author in connection with the study cited above also revealed that pastoral nomadism has also increased considerably ranging from 20 per cent to 50 per cent when judged from different criteria such as involvement of number of households, number and category of livestock, length of the period and distance covered during nomadic movements and frequency of movements during last ten years. The Socio-Economic Survey of Livestock Breeder in Anupgarh-Pugal Region of Western Rajasthan by Central Arid Zone Research Institute, Jodhpur, 1965, also observes that during the last five years the extent of nomadism is on the increase (See pp. 44-50). N. S. Jodha : A Semi-Nomadic Farm Family from the Arid Zone of Rajasthan also gives detailed account of this problem.