BIBLIOGRAPHIC DATA SHEET	1. CONTROL NUMBER PN-AAH-422	2. SUBJECT CLASSIFICATION (695) AP20-0000-G635

3. TITLE AND SUBTITLE (240)

The processes of desertification and the choice of interventions

4. PERSONAL AUTHORS (100)

Jodha, N. S.

5. CORPORATE AUTHORS (101)

Int. Crops Research Institute for the Semi-Arid Tropics

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1979	18p.	IN333.73.J63

9. REFERENCE ORGANIZATION (130)

ICRISAT.

10. SUPPLEMENTARY NOTES (500)

(In Economics Program, progress report no. 2)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Desertfication
Farming systems
Land reform
Agricultural technology
India
Arid land
Technology choice

13. PROJECT NUMBER (150)

931097200

14. CONTRACT NO.(140)

AID/ta-G-1421

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

IN
333.73
J63

PN-AAH-422

Progress Report 2
Economics Program

THE PROCESSES OF DESERTIFICATION AND THE CHOICE OF INTERVENTIONS

N. S. JODHA

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
1–11–256 Begumpet
Hyderabad 500016 (A.P.) India

JUNE 1979

THE PROCESSES OF DESERTIFICATION AND THE CHOICE OF INTERVENTIONS

N. S. Jodha

INTRODUCTION

The deliberations of the UN Desertification Conference at Nairobi (1977) and subsequent follow-up actions at national and international levels clearly indicate the increasing concern about the problem. Viable solutions call for understanding of the causes manifested by the decisions and practices of the ultimate users of the land in the arid or desert areas. This paper examines the process of desertification in the arid zone of Rajasthan, which accounts for nearly 63 percent of the tropical arid areas in India.

Notwithstanding the unsettled controversy over the expanding area of the Rajasthan desert, it is clear that desert-like conditions within the arid zone of western Rajasthan are becoming more accentuated. The following elements, resulting from unscientific land use, indicate progressive desertification: (1) growth of waste lands caused by loss of top soils or submersion of fertile lands under shifting sand dunes [Ghose, Panda and Singh 1968]; (2) conversion of fertile lands into patches of saline waste lands in the low-lying areas near seasonal streams [Anon. 1964]; (3) drying of dug wells or increased salinity of well waters [Anon. 1967]; (4) replacement of superior perennial species by inferior or annual (including nonedible) species in the grass lands [Prakash and Ahuja 1964]; (5) reduced productivity of

---

The author is Economist at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India, and wishes to thank Dayanath Jha, Hans P. Binswanger, and James G. Ryan for their valuable suggestions while preparing the paper. The author is grateful to ICRISAT for providing research facilities for preparing the paper. However, the views expressed do not necessarily reflect those of ICRISAT. Some of the ideas used in the paper were initially developed in two papers with larger scope (see Jodha 1978a, 1978b). The paper has the ICRISAT Journal Article no.93.

crops due to their extension to submarginal lands [Jodha 1972]; (6) increased extent of outmigration of people and animals to overcome the seasonal hunger gaps [Jodha 1966b]; and (7) increasing immiserization of inhabitants of arid lands due to increased impact of droughts and weakening of farmers' adjustment mechanism against drought [Jodha 1975, 1978c].

India's concern about the above problems and consequent corrective efforts have led to the adoption of measures ranging from the establishment of the Central Arid Zone Research Institute (CAZRI) for generating technological solutions to the initiation of area-specific development schemes like the Drought Prone Area Programme (DPAP) or the Desert Development Programme. However, neither technological options nor highly subsidized area-specific development schemes can help much, unless the process of desertification is properly understood. For the latter, it is essential to have an understanding of the traditional system of farming in the arid zone and the changes to which it has been subjected, particularly in recent decades.

THE TRADITIONAL SYSTEM OF MIXED FARMING

As indicated by the scientists as well as the traditional wisdom of the desert farmer, the bulk of the natural-resource base of the arid region is grazing land; and only a few pockets are good for sustained cropping [Jodha and Vyas 1969]. The consequence was the evolution of a system of mixed farming--including crop and animal husbandry--which matched the potential and limitations of the natural resource base. Livestock rearing ensures the stability of earnings (through seasonal migration) against spatial variability of weather. This helps in efficient utilization of lands unsuited to crop farming, and ensures benefit of complementarity between crop and

livestock farming at the regional level. Selective crop farming, even on submarginal lands, was attempted to take advantage of occasional high-rainfall years. The misuse of land (i.e. ploughing of land best suited to natural grasses) was rectified partly by a practice of crop rotation which included a long fallow (bush fallow) [Jodha 1978a].

The relative importance of the crop and livestock components of mixed farming did differ among rainfall zones of the arid region itself. A micro-level listing of mixed farming is presented in Table 1. Livestock accounts for a substantially larger share of the total asset value, as well as gross farm income, in drier areas like Jaisalmer. Its importance declines as the rainfall situation improves. A similar pattern has been observed at the macrolevel when aggregate district-level data are examined [Jodha 1977].[1] Furthermore, as indicated later, the traditional system initially had a number of institutional arrangements which prevented over-exploitation of resources through mixed farming.

The Changes in the System:

However, as revealed by microlevel data, the situation is fast changing. Pastoral people are now undertaking crop farming in addition to livestock rearing. For completely different reasons, more and more of the traditional cultivators are incorporating sheep raising and dairying as subsidiary occupations. Data from seven villages (Table 2) reveals that of the total households following mixed farming during the 1964-1965 period, 48 percent did

[1]It may also be added that within crop enterprises and livestock enterprises, the importance of drought-resistant crops like guar, mothbean, and pearl millet declines as one moves from drier to less-drier areas. Similarly in the drier districts, the proportion of animals like sheep, camel, and the preferred cattle breeds (like rathi) is higher than in the less-drier areas [Jodha and Vyas, 1969].

TABLE 1

DETAILS OF ENTERPRISE COMBINATIONS ON FARMS PRACTICING MIXED FARMING IN THREE AREAS OF ARID REGION OF RAJASTHAN*

District	Annual average rain-fall	Sample house-holds	Per-household details of land and livestock					
			Land	Animal units**	Relative share in total: Asset value		Relative share in total: Gross farm income	
					Land	Live-stock	Crop	Livestock
	(mm)	(no)	(ha)	(no)	(%)	(%)	(%)	(%)
Jaisalmer	179	43	32	40	18	82	26	74
Jodhpur	240	48	23	18	63	37	71	29
Nagaur	310	50	18	17	61	39	63	37

*Data were originally collected from three villages for the study of Capital Formation in Arid Agriculture [Jodha 1968]. They relate to the year 1964-65. Initial sample was 50 households in each village, but this table excludes those households who did not engage mixed farming.

**Consists of sheep, goat, camel, and cattle. Animal units are calculated on the basis of: 1 cow = 1 animal unit; 1 sheep/goat = 0.15 animal unit; camel = 1 animal unit [following Yang, 1965].

TABLE 2

CHANGES IN THE OCCUPATIONAL PATTERN OF HOUSEHOLDS WHO FOLLOWED MIXED FARMING DURING 1964-1965 IN SEVEN VILLAGES*

District	Total households following mixed farming	% households who did not have the following occupation prior to 1954		
		Cultivation	Sheep/goat rearing	Dairying
Jaisalmer	172 (26)**	78	9	7
Jodhpur	188 (23)	34	32	19
Nagaur	264 (18)	38	36	12
Total	624 (67)	48	28	13

* For source of data, see note "a", Table 1.

** Figures in parentheses indicate number of farm households who did not practice mixed farming.

not do cultivation prior to 1952-1954, the peak period of land reforms. Similarly 28 percent did not list sheep/goat raising among their occupations. The situation differs from district to district, but the extent of mixed farming is on the increase. Though an efficient and beneficial system from the view point of private individuals, the increase in mixed farming (in the context of arid region as a whole) has also led to the extension of plowing to submarginal lands suited only to natural grasses and to overstocking of fast-shrinking grazing space.

At the aggregate level for the arid regions as a whole, the above changes are reflected through the following:

For the arid region of Rajasthan, net area under crops (6.6 million hectares in 1951) increased by 49.5 percent by 1961. This was the peak period of implementation of land-reforms [Jodha 1966a]. During the next decade, the area under crops further increased by 13 percent [Mann and Kalla 1977]. There has been a corresponding decline in the land-use categories described as cultivable waste and barren lands, which are nothing but grazing lands (excluding the very limited designated permanent pastures). The net situation is that in the arid region where, as per the FAO land-use capability classification for soil conservation, only 21 percent of the land is suitable for sustained cropping [Jodha and Vyas 1969], nearly 49 percent of the area is used for cropping. This figure would be greater if the cropped area is viewed in the context of the total geographical area, excluding the area not available for agricultural use.

Livestock expressed in animal units, numbered 4,697,000 in 1951.[2] By 1961, this had increased by 45 percent, followed by a further increase

[2]See Table 1, note b, for explanation of "animal unit."

of 5 percent during the next 5 years. Correspondingly, the density of livestock per 100 hectares of grazing space (including permanent pastures, cultivable waste, current and bush fallows, barren and uncultivable lands) has increased from 36 animal units in 1951 to 62 and 67 animal units in 1961 and 1965, respectively [Jodha and Vyas 1969]. The effective density is much more, as the animal pressure is concentrated around watering places--which have been turned into barren grassless patches.

THE PROCESSES OF DESERTIFICATION

Changes which have occurred are the outcome of forces influencing farm-level decisions. In an attempt to gain understanding of the desertification process, these forces will be diagnozed through the employment of microlevel illustrations.

At the microlevel, the two forces which induce the farmers to over exploit the land resource base are (1) increased subsistence requirements and (2) apparent increases in the profitability of exploitating arid lands.

These forces in turn are a product of certain public interventions which, at least in the short run, have accentuated the over-exploitation of land resources, part of which would have taken place due to the secular growth in the pressure on land. Elaboration of these points calls for understanding of the back-wash effects of well-intended interventions and institutional and other changes in the arid region of Rajasthan. These changes are (1) reduced isolation and increased market integration of arid areas with other regions [Jodha 1978c], and (2) the government's land-reforms policies, which have completely disregarded the limitations of the land-resource base in the region [Jodha 1970]. These two factors have been positively associated with development elsewhere, but in the arid zone their indirect impact has proved damaging.

Effects of Improved Market Infrastructure on Arid Lands:

The first factor which initiated change in the traditional system of farming was reduced physical and market isolation of the arid areas.[3] This had two major implications. It ensured quick relief supplies to arid areas during droughts, and reduced drought distress. Human deaths due to famine became a thing of the past. Animal casualties during scarcity years were much fewer. The role of droughts as levellers of pressure on the land disappeared. However, relief and resource transfers--being temporary devices for crisis periods--always resulted in subsequently increased pressure on land after every drought. Every intervention in terms of relief, though well intended, by another logic seems to have sowed the seeds for the next crisis with higher severity because it protected the increased pressure on resource base without strengthening the resource base itself.[4] Improved

[3]An idea of reduced physical isolation of the areas can be had from the change in network of roads in the arid areas. During the 1942 famine year (for which some data are available with the Revenue Settlement Department), the density of all-weather roads in arid areas constituting the former princely state of Jodhpur was 6 km per 100 km^2 of area. This changed to 17 km per 100 km^2 in 1965. Furthermore, in 1942 not more than one-third of the districts had direct all-weather road connection to the state capital. By 1965 not only state capital and all districts had metal road links, all subdivisions (*tahsils*) within districts became linked by road. In 1942 it used to take 2 days to cover the 130-km distance between villages in Jodhpur and Nagaur, for want of better means of communication. By 1965, one could make two trips between the same places within a day, because of good roads and regular bus services. Most of the roads were constructed by means of famine-relief works.

[4]An analysis of famine-relief expenditure by the government showed that under relief works the share of resource-development activities, including soil conservation and minor irrigation, accounted for only 5 percent of total expenditure. Road construction, as relief-employment work, accounted for 88 percent of the expenditure [Jodha 1969]. The implication is obvious. It helped in physically integrating the areas; and was conducive to increased exploitation of the natural resources (by extended markets), without improving the productive capacity of the resource to efficiently match the demand.

means of communication also improved health and medical facilities, which also contributed to population growth, as in other areas.[5] The second implication was the increased opportunity to market products of arid areas. This resulted in higher ex-village prices for farm products (Table 3), particularly for the livestock products and pulses in which arid areas have comparative cost advantages [Jodha 1972].[6] The farming system became more market-oriented and the farmers more profit-minded. Increased demand and strong profit motives, unaccompanied by simultaneous improvement in production base, could only result in over-exploitation of the resource base. This seems to have happened in the arid region of Rajasthan. Hopefully this is a transitional phase, preceding investment in resource improvement on both public and private account.[7]

---

[5]Census data reveal that population growth during the last two decades was consistantly higher in the arid part of Rajasthan than in to Rajasthan State as a whole. During 1901 to 1971, population in the arid zone increased by 186 percent, while for the state as a whole it was only 150 percent. For India in total, growth during the same period was 132 percent [see Malhotra 1977].

[6]For instance most of the animals, especially cattle, were sold in the four or five traditional cattle fairs at the beginning of the seasons. Sheep and goat and their products, as well as dairy products, used to be accumulated for months together and then sold once or twice a year. The new facilities have made it possible to sell almost daily or weekly. Traders used to visit the villages with carvan of camels or bullock carts once or twice a year and buy surpluses of grains, wool, and ghee (cleared butter). In the changed situation, trucks visit the same villages almost every week as long as marketable supplies of products are there. In recent years, because of government dairy-development schemes, milk from the villages is collected every day [Jodha 1968].

[7]There is no well-documented evidence, but field observations reveal visible increase in wells, tube wells, tractors, improved milch cattle, etc., through private investment, including that induced by public support. The infrastructural support for resource development through Rajasthan Ground Water Board, Rural Electrification Corporation, Dairy Development Program, and Public Financing Institutions has also become effective--at least in some parts of the arid region--since late 1960s. However the problem of submarginal areas exposed to overgrazing and overplowing have not yet received specific attention.

TABLE 3

PRIVATE COST (TAXES, ETC.) OF LAND USE DURING THE PERIODS BEFORE AND AFTER LAND REFORMS IN SOME VILLAGES OF THE ARID REGION OF RAJASTHAN*
(All values at 1976-1977 prices)

Particulars	Situation during	
	Preland-reforms period (1950-51)	Postland-reforms period (1964-65)
(A) Better crop land (Chahi):		
Pearl millet yield (kg/ha)**	520	520
Times cropped in 5 years***	4	5
Land revenue (rent) (Rs/ha)†	83	6
(B) Submarginal land (Barani):		
Pearl millet yield (kg/ha)**	200	200
Times cropped in 5 years***	2	3
Land revenue (rent) (Rs/ha)†	16	1.5
(C) Pearl millet average cost of production (Rs/ha):	-	285
(D) Grazing land (Gochar):		
Grazing tax (Rs/animal)	1.25	-
Other livestock-related levies/ penalties (Rs/household)	23	-
Value of contribution to protection/ maintenance of pasture/tank, etc. (Rs/household)	18	-
(E) Animal-product prices, etc.:††		
Wool (Rs/100 kg)	90	480
Ghee (Rs/kg)	5	18
Milk (Rs/litre)	-	0.60

*Details relate to a cluster of three villages in Nagaur district. Data collected from village records and interviews during field work in 1963-66 for a study of Capital Formation in Arid Agriculture [Jodha 1968].

**Pearl millet yields as recorded during 1964-65 on both types of lands.

***Frequency of cropping due to the practice of periodical fallowing of land. This also indicates the number of times when rent 25% of crop produce) was paid during preland-reforms period.

†Land revenue during the preland-reforms period was charged in the form of 25 percent of the grain yield of the plot whenever it was cropped. The annual rent has been calculated by multiplying the money value (at 1976-77 prices) of crop share by number of years when land is cropped and dividing by five. During land reforms, the land revenue at much lower rate was fixed on permanent basis as indicated in the table.

††Prices as obtained in the villages.

Impact of Land Reforms:

The purposes of this section is not to belittle the gains of land reforms and thus indirectly idealize the traditional feudal system of land ownership; the point to be emphasized is that the traditional system did possess certain features which contributed to the conservation and controlled use of the land resources in the arid zone.

In Rajasthan land reforms, particularly the abolition of the feudal form of land ownership and village administration, distribution of ownership rights to tenants and landless people, and fixation of land-revenue rates, etc., were largely completed during 1952-1954. Its consequences, relevant to our discussions, included the following:

(1) Land reforms helped in the distribution of submarginal lands for crop farming. During the peak period of land distribution, the cropped area increased from 6.6 million hectares in 1951 to around 10 million hectares in 1961. Most of these lands were suitable only for natural pastures.

(2) Equally important was the effect of land reforms on cost of land use--both for cropping and grazing. For instance according to the tenurial arrangements under feudal system, a farmer had to pay between 25 to 75 percent of his crop as rent in kind to the *Jagirdar*.[8] This meant that rent alone accounted for a substantial share of cost of cultivation.

The *Jagirdar* also imposed animal-grazing tax (called *ghas-mari*) and periodic free gift (called *laag*), especially from bigger herds of sheep and goat. He imposed severe penalties on graziers for violation of regulations

[8]Feudal landlords called *Jagirdars* owned all the village lands. The citizens of the village, essentially tenants of the landlords cropped the land on crop-share basis. For the use of grazing land, taxes in cash and kind were collected by the landlords. It was also their privilege to take free gift (*laag*) from their tenants on the eve of any ceremony at their house or at the house of a tenant [Jodha, 1968].

designed for controlled grazing and water use from *Tobas* (tanks), as this formed an important source of revenue for him.

With the abolition of feudal arrangements, most of the exploitative features of tenurial system disappeared. Large rents were replaced by lower and permanently fixed land revenue. Penalties and taxes on animal grazing also disappeared. Despite legal provisions, the taxes could not be re-imposed by village *Panchayats* which inherited the function of village administration. The village *Panchayats*, subject to election by popular vote, are sensitive to the impact of such taxes on voting citizens. Village factionalism, accentuated by *Panchayat* politics, weakened the informal institutional arrangements (e.g. *Chaitra*, i.e. zoning of grazing areas) for resource conservation and regulated use. This also led to complete disappearance of some items of private cost in terms of contribution of labor, etc., towards protection/maintenance of grazing lands, shelterbelts (*matt*), water tanks (*Tobas*), etc.

The final consequence is a drastic reduction in the cost of land use for both cropping and grazing. Table 3 sums up the situation for three villages in Nagaur District. Accordingly, on better crop land a farmer paid around Rs.83/hectare as kind rent (expressed in 1976-77 prices) prior to land reforms. After land reforms he paid only Rs.6/hectare. On submarginal lands, the corresponding amounts are Rs.16 and 1.5 per hectare. The livestock-related expenditure of land use (excluding grazing fee) was Rs.47 per household prior to land reforms, and zero after the land reforms. Grazing fee also came down to zero from the earlier Rs.1.25 per animal. Wool and milk prices, on the other hand, increased manyfold during the period, largely due to widened markets and better means of transport. Table 3 describes the situation in a cluster of villages in Nagaur District; with

minor differences it could apply to other areas too.

To sum up, the reduction in physical and marketwise isolation of arid areas, along with welfare-oriented egalitarian institutional (land reforms) changes, induced a process which accentuated the rate of exploitation of an already deficient and rapidly-depleting resource base. At the microlevel, the operating mechanism is as follows:

1. The bulk of people have to manage their subsistence out of a per-capita reduced natural resource base of progressively declining productivity. Attempt is made to compensate for lower per-unit productivity by spreading production effort on larger units.[9] This is done both by extending plowing to submarginal lands and reducing the practice of periodic resting of the land, particularly through long fallows.[10]
2. In the case of livestock, they seem to maximize gains through larger flocks and herds which could subsist on degraded pastures rather than through high quality animals requiring better quality of land-resource base and higher extent of private cost [Jodha and Chaudhuri 1970].
3. The role of compulsion to over-exploit resources, mentioned earlier, is complemented by inducement to over-exploit. The inducement is in the form of reduced private cost of resource use in terms of taxation, rents, or contributions through informal institutional arrangements for resource protection. The lower cost, complemented with improved marketability and profitability of animal products, further strengthens the tendency to over-exploit the resources.

---

[9]The average availability of cultivable land per household has declined from 13.7 ha in 1951 to 6.0 ha in 1971 [Malhotra 1977].

[10]The extent of long fallow (bush fallow) as a proportion of total geographical area has declined by 8 percent during 1951 to 1961 and further by 23 percent during the next decade [Jodha 1966a, Mann and Kalla 1977]. Furthermore, as expected, the extent of long fallow declines with the decline in farm size during this period [Jodha 1977].

REMEDIAL MEASURES

The reversal of the resource-exploitation process should start with neutralizing the factors listed above. This calls for a suitable mixture of technological and economic measures to deal with specific situations.

However, at the outset it may be that the spurt in resource over-exploitation could hopefully be a transitory phase. It is not an uncommon experience in history, where (facilitated by new infrastructure) people heavily exploited the existing resource base and only when pushed to the limit was the need for conservation and development of resource base realized. As mentioned earlier, the field observations in arid areas of Rajasthan do suggest some progress in resource development through private and public investment. Progress in some pockets--in terms of minor irrigation, dairying and sheep development, and tractorization (to counter the constraint of a very short wet period [Jodha, 1974])--under various development schemes such as the Drought Prone Area Programme (DPAP) serves to illustrate the point. If the process of resource development continues, it will help reduce risk-related and subsistence-related forces inducing over-exploitation of the land-resource base. Thus the investment in resource development recommends itself as one of the key areas of public policy. This is good as far as it goes. In view of the scarcity of usable ground water and limited scope for importing water from neighboring regions, the scope for agricultural-resource development is closely linked to the availability of technology relevant to the low and uncertain rainfall situations characterizing the arid areas.[11]

---

[11] In view of absence of abundant minerals and noncongenial environment for foot-loose industries, the economy of the region will have to remain agro-centred in the foreseeable future.

Technological Options:

The Central Arid Zone Research Institute (CAZRI) has been engaged during the last two decades in evolving relevant technology for arid lands. The institute has been able to assess the extent of resource degradation due to unscientific use and have evolved various methods to upgrade and efficiently use it. Various measures evolved for stabilization and increased productivity of grazing lands and crop lands include stabilization of shifting sand dunes; regeneration of range lands through reseeding, ridges and contour trenching, etc.; creation of shelterbelts and microwind breaks, and a number of additional moisture-conservation measures and agronomic devices to help crop farming in low-rainfall situations.[12] However, except for recently initiated operational research projects in a few villages, the CAZRI technology has not been tested on farmers' fields. Thus it is difficult to comment on technological options really available to arid agriculture. At the same time juxtaposition of technology in pipe line and objective circumstances obtaining in the arid areas of Rajasthan suggests the following:

(1) Complementarity of seed-centered and resource-centered technologies: In view of adverse environmental conditions, particularly low and unstable moisture, the seed-centered technologies cannot yield to their full potential in arid conditions unless soil-moisture conservation devices are adopted simultaneously. This applies to both crop lands and pastures. The adoption of a total package involving both types of technologies add to the costs which the farmer, with a very narrow time horizon and limited resources, cannot associate with returns [Jodha, 1968]. This makes the cost factor a major deterrent to adoption of

[12]For a summary of these measures, see Jodha and Vyas [1969], Mann and Singh [1977], Ahuja [1977], and Kaul and Chand [1977].

new technology in arid areas, and in turn calls for generation of low-cost technology and provides justification for subsidies for resource development under schemes like DPAP.

(2) Individual viz. Group Centered Technology: As mentioned earlier, most of the resources-conservation measures, ranging from sand-dune stabilization and contour bunding to controlled and regulated grazing, cover more than a farm or even a village--depending upon their catchment. Thus, to a greater extent, the resource-conservation and -management technologies for arid areas are group centered. Hence, their adoption is difficult to motivate, especially in view of the present approach of over exploitation of a common resource for private gain. Hence a need for institutional arrangements to ensure collective action on the part of the beneficiaries of new technology [Jodha, 1968]. However, such group action is difficult unless the technology is profitable to private individuals to begin with [Doherty and Jodha 1977].

It may be noted that increased resource productivity cannot permanently keep the pressure on land less than its carrying capacity. The higher the productivity, the greater will be the temptation to over-exploit, unless nece-necessary fiscal devices such as progressive taxation on land use are adopted to ensure resource use within the limits.

Control of Profit-Related Over Exploitation: Reduced cost of land use and increased profitability of products, as mentioned earlier, have greatly accentuated resource exploitation. Regulation of resource use through fiscal measures is a well-established part of state policy. However, this has never been tried in the case of arid lands in Rajasthan. As indicated (Table 3), land revenue is the only tax now paid by the land user. This tax is rather an ownership tax and it is in no way related to the productive capacity of the resource base. Moreover, for use of public lands for grazing there is no tax at all.

Though there is no justification for raising land tax to the old level of feudal rents, as even the irrigated farms are not taxed that heavily at present. Yet there is a clear case for taxation linked to the degree of land exploitation for cropping and grazing.

For operational convenience, progressive taxes could be based on a number of grazing animals or on income from land use. These are broad indicators of the extent to which one benefits from exploitation of resources. Tax rebate may be given to those who adopt conservation measures. To neutralize the inegalitarian implication of taxing users of arid lands who are already poorer than farmers in irrigated areas, arrangements may be made to reinvest revenue from these taxes for development of the arid lands themselves.

Another institutional measure to reduce overexploitation relates to grazing rights. Provision of grazing rights with flexibility to reward those who conserve the land and panalize those overexploiting the land can prove a useful device.

REFERENCES

Ahuja, L.D. 1977. "Improving Range Land Productivity." (In *Desertification and its Control*), Indian Council of Agricultural Research (ICAR), New Delhi.

Anon. 1964. *Scientific Progress Report of CAZRI (1964-65)*. Central Arid Zone Research Institute, Jodhpur, India (mimeo).

Anon. 1967. *Quarterly Report on Preliminary Geohydrological Survey of Jodhpur-Nagaur Sector*. Report S & I, Vol.2, Rajasthan Ground Water Board, Jodhpur, India (mimeo).

Doherty, V.S., and Jodha, N.S. 1977. *Conditions for Group Action Among Farmers*. Occasional Paper 19, Economics Program, ICRISAT, Hyderabad, India.

Ghose, B., Pande, S., and Singh, S. 1968. "Process and Extent of Erosion and its Effect on Land Use." *Annals of Arid Zone*, Vol.7(1).

Jodha, N.S. 1966a. "Scarcity Oriented Growth Pattern of Arid Agriculture." *Indian Journal of Agricultural Economics*, Vol.XXI(4).

Jodha, N.S. 1966b. *Pilot Survey of Salawas Village*. CAZRI, Jodhpur, India (unpublished).

Jodha, N.S. 1968. *Capital Formation in Arid Agriculture*. (Ph.D. Thesis), University of Jodhpur, India (unpublished).

Jodha, N.S., and Vyas, V.S. 1969. *Conditions of Stability and Growth in Arid Agriculture*. Agro-Economic Research Center, Vallabh Vidyanagar, Gujarat, India.

Jodha, N.S. 1969. "Drought and Scarcity in Rajasthan Desert : Some Basic Issues." *Economic and Political Weekly*, Vol.IV(16).

Jodha, N.S. 1970. "Land Policies of Rajasthan : Some Neglected Aspects." *Economic and Political Weekly* (Quarterly Review of Agriculture), Vol.V(26).

Jodha, N.S., and Chaudhari, K.M. 1970. *Problems and Prospects of Dairy Development in Desert Region of Rajasthan*. Agro-Economic Research Center, Vallabh Vidyanagar, Gujarat, India (mimeo).

Jodha, N.S. 1972. "A Strategy for Dryland Agriculture." *Economic and Political Weekly* (Quarterly Review of Agriculture), Vol.VII(13).

Jodha, N.S. 1974. "A Case of Process of Tractorization." *Economic and Political Weekly* (Quarterly Review of Agriculture), Vol.IX(52).

Jodha, N.S. 1975. "Famine and Famine Policies." *Economic and Political Weekly*, Vol.X(41).

Jodha, N.S. 1977. "Land Tenure Problems and Policies in the Arid Regions of Rajasthan." (In *Desertification and its Control*) ICAR, New Delhi, India.

Jodha, N.S. 1978. "Production Patterns and Dynamics of Resource Use in Arid and Semi-Arid Tropical India." Paper presented at CLIS-Seminar on *Optimizing Agricultural Production Systems*, Bamako, Mali, 22 Feb - March 1, 1978.

Jodha, N.S. 1978b. "The Operating Mechanism of Desertification and Choice of Interventions." Discussion Paper 5, Economics Program, ICRISAT, Hyderabad, India (mimeo).

Jodha, N.S. 1978c. "Effectiveness of Farmers' Adjustment to Risk." *Economic and Political Weekly*, Vol.XIII(25) (Quarterly Review of Agriculture) 24 Jun 1978.

Kaul, R.N. and Chand, Gyan. 1977. "Forest Tree Planting in Arid Zones." (In *Desertification and its Control*) ICAR, New Delhi, India.

Malhotra, S.P. 1977. "Socio-Demographic Factors and Nomadism in the Arid Zone." (In *Desertification and its Control*) ICAR, New Delhi, India.

Mann, H.S., and Kalla, J.S. 1977. "Asset-Liability Imbalances in Agricultural Sector of the Indian Arid Zone." (In *Desertification and its Control*) ICAR, New Delhi, India.

Mann, H.S., and Singh, R.P. 1977. "Crop Production in Indian Arid Zone." (In *Desertification and its Control*) ICAR, New Delhi, India.

Prakash, M., and Ahuja, L.D. 1964. "Studies in Different Range Condition Class Grasslands in Western Rajasthan." *Annals of Arid Zone*, Vol.3 (1 & 2).

Yang, 1965. *Methods of Farm Management Investigation*, Food and Agricultural Organization, Rome.