TRANSFER OF TECHNOLOGY FOR DESERT MANAGEMENT : A COMPARATIVE STUDY OF INDIA AND ISRAEL

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MASTER OF PHILOSOPHY

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CERTIFICATE

Certified that the dissertation entitled **"TRANSFER OF TECHNOLOGY FOR DESERT MANAGEMENT : A COMPARATIVE STUDY INDIA AND ISRAEL"** submitted by **Manoj Kumar** in fulfillment of nine credits out of total requirements of twenty four credits for the award of degree of **MASTER OF PHILOSOPHY** (M.Phil) of this University, is his original work and may be placed before the examiners for evaluation. This dissertation has not been submitted for the award of any other degree of this University or of any other University.

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MANOJ KUMAR

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CHAPTER - I

INTRODUCTION

1.1 Statement of the Problem

Desert Management is the process to control the desertification which is a complex form of mal-adjustment between interacting forces of physio-biotic environment and their users. The natural deterioration of land resources (soil, vegetation and wild life) may follow some long term physical changes within the earth system. This is a change causing ecological imbalance. Hence it is imperative to control and stop the process of desertification.

Man interacts with the environment and the economic progress results in the deterioration of environment. The desertification is process which is primarily only account of man but role is also played by natural factors like low precipitation, high evaporation, shifting of sand dunes, low water table, less vegetation, etc.

In the preceding decades, there was tremendous advances in environmental ethics. It is now aimed to have the sustainable earth with its all resources. It is believed that humans are part of nature and for our needs, we should work with nature. Plants and Animals habitats maintain themselves and their given eco-system. It is the man with greater mobility and sustained energy, who intervenes with the eco-system to make a profitable existence. For short range profitabilities, man may even break the natural eco-system adversely, reducing the quality of environment. Initiating desertification step by step to reach a point of no return.

Desert is regarded as a extra territorial realm which is separated from other two territorial realm - one is oceans and the other is habitable land. The people of habitable land find it impossible to sustain in the desert. With the passage of time, man took initiatives in the desert area and sought some locations, where he sustained himself. In many parts of the desert areas of world, the new technology make possible the reclamation of what had so long been considered as wasteland. The best result is visible in Israel. It was necessary to develop and colonize the desert to meet the growing demands.

It is a common placed interest of the world that how to use the resources of earth to sustain the eco-system of the earth. The utilization of the technology to improve the condition of desert is a challenging task.

Desertification can be described as a process during which environmental degradation of natural resources occurs with an associated loss of biological productivity. There are many stages in process, but the final stage is that of complete desert with zero level biological production.

Desertification is far from novel experience for mankind, it has influenced the rise and fall of civilizations throughout history like Babylonians and Sumerians had their agricultural production destroyed by salinization of their irrigated land. It has been proved that land lost its capacity to bring productivity. Desertification in poorer, less developed country like India brings greater poverty, with resulting increase in malnutrition and disease and general deterioration of the nation's social fabric. It is practically very difficult for people living in high water table areas to drink water of low water table areas because it is seen practically that too much of impurity is there but there is no option except to drink that unhygienic water. Similarly, so much malnutrition is there in desertic areas which causes several incurable diseases. These areas are generally called backward areas because people living here have very less productive capacity and have very low income levels; on the other hand, Government have also some restrictions or incapable of improving the standard of living of these areas because not only there is not only difficult to develop some technology but due to illiteracy and poverty, the technology is not adopted by the people. In India, agency like CAZRI have shown some serious interest to develop some technologies and also diffuse this technology by themselves by organizing various extension programmes. The desert management is, therefore, is a need of today.

Man is struggling against the aridity and using different trial and error method and has made success in some parts of the world like in Israel. These results have come through after successful experiences. However, it is noticed that the quality of life of arid regions has remained poor in spite the great cultivators have flourished in these regions. Therefore to attain a good standard of living for desert people, scientific knowledge and developmental technology for optimum use of available resources become increasingly important.

The general problem of arid and semi-arid areas with large populations is essentially one of human ecology. In absence of adequate scientific knowledge and prevailing attitudes, the local population has over-exploited the natural resources resulting in an ecological imbalance. Where large scale water from outside the arid regions cannot be tapped, the inherently meagre and fluctuating water resources within the region set the ultimate limit to production of plant material which sustains both human and animal population. Erratic rainfall results in fluctuating production. This in turn leads to frequent scarcities.

As the population increases the stress becomes greater. Eventually there is an increasing rate of imbalance between human and animal population on the one hand and plant, water and land resources on the other. As the human demands persist and intensify the resources tend to become further depleted. Thus, there is set into operation a process of progressive desertification. If continued unchecked, it leads to permanent damage to vegetation through excessive grazing or cutting for fuel leading to their replacement by bare land or at best by less useful plant communities to the loss of surface soil by water or wind erosion to lower soil fertility and ultimately to the production of large areas of waste land or barren sand dunes which are not only unproductive but may involve considerable public expenditure where they encroach on community services.

1.2 Desertification - Indian Scenario

India is facing on its western (north-western part), the acute problem of desertification. The Indian desert is located in western part is Rajasthan, North Gujarat, Punjab and Haryana. To combat this problem, efforts were made very early in the twentieth century, the government established the National Institute of Science (Indian National Science Academy) which recommended the Desert Afforestation Station renamed Central Arid Zone Research Institute.

The arid zone and semi-arid zones in India is spread over eight states but 90 per cent of the hot desert is located in the north western part of India out of which 61 per cent is located in the state of Rajasthan. The Government of India and the state government in arid and semi-arid zones realized the alarming situation and reacted promptly. These government bodies provided funds for anti-desertification programmes, established infrastructure to study the problems, evolved strategies to minimize the hazards of desertification and provided for transfer of appropriate technology. They have also organized result-oriented extension programmes by creating appropriate agencies.[1]

Desertification is not yet viewed as a serious ecological problem in developmental planning in India. Although 14 per cent of the world's land is threatened by desertification lie in India. There are only some ecological movements in the country which are in one way or another can be considered a response to increasing trend of desertification in humid as well as of arid zones; uplands as well as of low lands. Desertification is a threat under extremely low rainfall conditions, and wherever the soil-

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1. Jain, J.K. 1988. Desertification in India, Extent, causes and control in Desertification, Monitoring and Control ed. A.K.Tiwari Sci. Pub. Jodhpur, pp.221-235.

vegetation system becomes incapable of conserving moisture and this can happen even under conditions of high rainfall as in Himalayas in Indian situation.

Indian desert have some physiographic observation, the rivers are misfit and soon die out due to alluvial suffocation. The drainage except the Luni and Mendah which has its origin in the region of very high rainfall and thus capable of forming its own valley is mostly internal and there are no permanent flowing rivers.[2]

There is no network of integrated drainage system and no controlling level to which the landscape is lowered. Instead to which the landscape is lowered. Instead, the rivers deposit their load. The debris resulting out of gullying and dissection of mountains are accumulated in the interment basins, Alluvial sand becomes laterally confluent and continuously slopping `bajadas' are formed along mountain fronts and all these geomorphic factors are characteristic of an arid climate and all found exclusively in areas receiving less than 500 mm of annual rainfall.[3]

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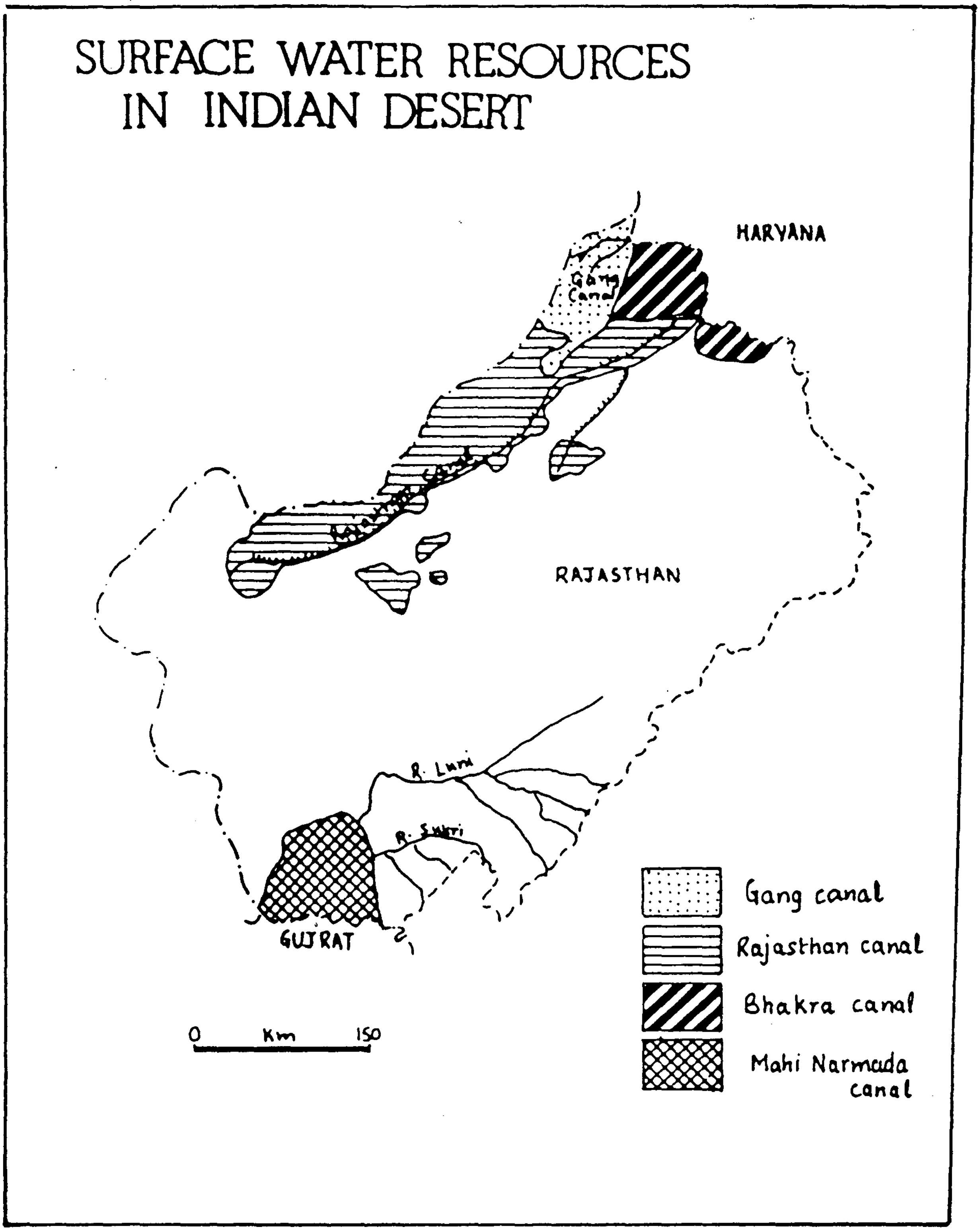
2. Sen, A.K. 1988. Environmental degradation due to desertification in Rajasthan Desert in Desertification, Monitoring & Control ed. A.K.Tiwari Sci.Pub., Jodhpur, pp75-99.

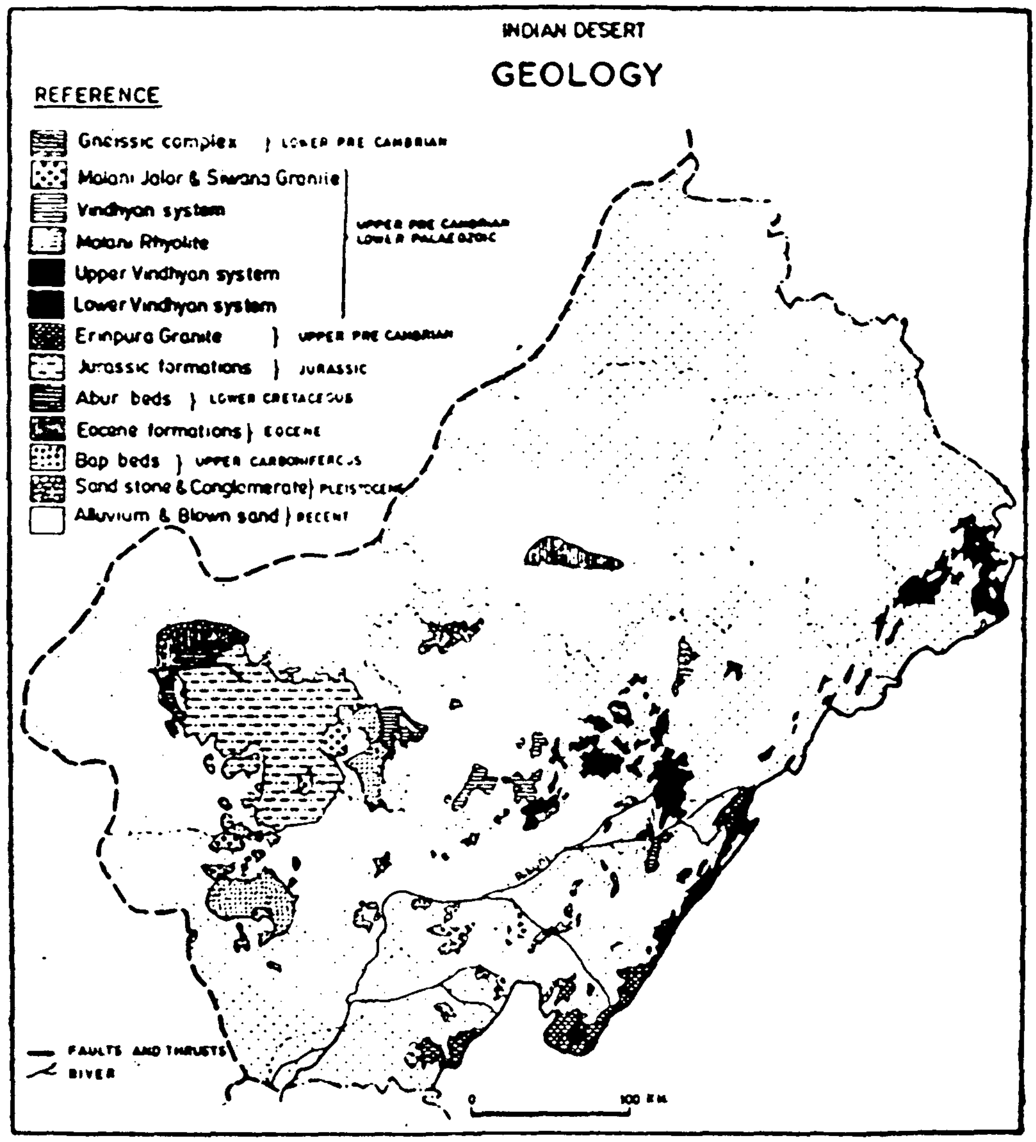
3. Jain, J.K. 1988. Desertification in India, extend, causes & control in Desertification Monitoring and Control, Ed.A.K.Tiwari Sci.Pub., Jodhpur, pp.221-235.

Map No. i


SURFACE WATER RESOURCES
IN INDIAN DESERT
HARYANA
Gang Canal
RAJASTHAN
R. Luni
R. Sukri
GUJRAT
0 Km 150
Gang canal
Rajasthan canal
Bhakra canal
Mahi Narmada canal

The great Indian desert of Western India as such extends approximately between 21°N and 31°N and between 69°E and 76°E comprising an area of about 295,000 sq. km. A subsidence in the Ganges delta aided by later uplift during sub-recent times in the Aravalli-Delhi axis led to the gradual rise of Eocene sea floor of the Indian desert. This resulted in the shifting of the Yamuna, which was hitherto a tributary of the Saraswati of the Indus System (the combined stream of the Saraswati and Yamuna was known as Ghaggar) to the Ganges system (Oldham, 1986). The increased aridity due to rise of the Himalayas and lowering of the Aravallis probably caused the shifting and desiccation of the rivers like the Saraswati that made the desert gradually uninhabitable and made the people of Saraswati and the Ghaggar valley as nomadic, uneconomic exploitation of resources and deforestation contributed little to this deterioration. This is purely a climatic and physiographic phenomenon of the Indian desert as in others tropical and sub-tropical deserts of the globe. not man-made. But it is human activities; uneconomic exploitation of resources and land use practices and other biotic interference that have

Map No. ii


INDIAN DESERT
GEOLOGY
REFERENCE
Gneissic complex } LOWER PRE CAMBRIAN
Malani Jalor & Siwana Granite
Vindhyan system
Malani Rhyolite
Upper Vindhyan system
Lower Vindhyan system
UPPER PRE CAMBRIAN LOWER PALAEOZOIC
Erinpura Granite } UPPER PRE CAMBRIAN
Jurassic formations } JURASSIC
Abur beds } LOWER CRETACEOUS
Eocene formations } EOCENE
Bap beds } UPPER CARBONIFEROUS
Sand stone & Conglomerate} PLEISTOCENE
Alluvium & Blown sand } RECENT
FAULTS AND THRUSTS
RIVER
0
100 KM

made the desert more and more uninhabitable.[4]

Some of the main human and biotic interference that are causing the deterioration of the Rajasthan desert are given below:

1. Uneconomic land use - Cultivation on the sand dunes and marginal lands affecting adjacent fertile lands and is a menace to soil erosion. This has caused reactivisation of sand dunes in canal command area at Nachna.
2. The intensive and uneconomic use of canal irrigation.
3. Extensive use of water resources leading to the rise of water tables, seepage problems and increased salinity Prikampur Chinnu and Nachna area of Jaisalmer district.
4. Uncontrolled grazing and indiscriminate cutting of trees leading to soil erosion and increased desertification hazards especially at Kuri area near desert National Park in Jaisalmer district.

The inherent vulnerability of land and intense biotic pressure along with human use and adaptation lead to deterioration of environment and helps in process of desertification. Important biotic factors in Indian desertification are like desertification due to over-

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4. Rama Krishna. 1988. Climate changes in relation to desertification in Indian and zone in Desertification, Monitoring & Control Ed. A.K. Tiwari, Sci.Pub. Jodhpur, pp.99.

exploitation of resources and uneconomic land use practices. Due to intense pressure on land and absence of subsidiary occupation compel the people dentally Indian arid zone is highly densely populated desert of the world. This causes loosening of sand particles which become susceptible to be carried by winds and these winds bounce sands fall on the adjacent fertile lands and ultimately deteriorate them.

The livestock population and that of pressure on grazing land in Rajasthan is considerably high (Table 1 & 2). The result has been over grazing and deterioration of the surface vegetation conditions largely responsible for increased desertification hazard. In Western Rajasthan in view of their low carrying capacity, the increased pressure of livestock on grazing lands result in over exploitation of resources leading to depletion of consequences on settlements, commercial and other infrastructure like Nachna, Churu, etc. This is also a menace to soil erosion leading to the removal of surface vegetation and soil. The absence of organised livestock farming is strongly felt. This also cause the shifting of sands which often cover the existing settlements and even the hills. A hill towards the north-east of Barmer town which has been reported 60 years back to be free of sand is now almost buried. Sand dune fixation works undertaken about fifteen years back has partially stopped this serious catastrophe. Uncontrolled grazing (over-grazing) is often added with indiscriminate cutting of trees and lopping to make the desertification hazard more intensive.[5]

Over-exploitation of ground and surface water resources for intensive and uneconomic use for irrigation leads to the rise of water table, seepage problems, water-logging and increased salinity.

Uneconomic and intensive uses of canal water in the Ganga nagar, Bikaner and Jaisalmer districts have developed some alarming problems. In Gang canal and Rajasthan canal command areas in Ganganagar district due to sandy terrain and seepage losses from main canal, distribution and field channels, the ground water level is rising at an alarming rate of 0.43 to 0.83 in per year. In the Ghaggar flood area around Suratgarh, Borpal, Manekthar areas water table has risen by 6-5 metres within path twenty years. Due to this rise of water level 6920 cm. mcm water is being added to aquifer annually leading to the developments of soil salinity (Kallar) in many places. The increase of water table and Ghaggar flood has caused water logging problems in inter-dune areas (23 interdune areas near Suratgarh has already been submerged and become permanently water logged). Canal irrigation on sand dunes and marginal lands in Nohal

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5. Krishnan, M.S., 1952. Geological History of Rajasthan and its relation to present day condition. <u>Bul.Nat. Inst. S.</u> No.1, pp.19-31.

and Bhadra area of Ganganagar and Lunkaransas area of Bikaner districts are causing the fresh deposition of sands, formation of new sand dunes and other environmental degradation in Churu (Sardarsahar- Ratangarh-Taragarh area), Sikar and Jhunjhunu districts. Churu district has recently shown considerable increase of desert sand, sand drifts and the existing stabilized dunes are increased vertically and new sand dunes are developing around Churu Taragarh, etc.[6]

Sand dunes are not universally sand wastes. These are rather often cultivated during rainy season. The active sand dunes are often wastelands but the lower and middle flanks of these dunes are cultivated in years of very good rainfall, particularly in rainfall zone of over 200 mm upper flank and crest of the dunes serve as grazing ground of the livestock. So Indian desert, the land use of sand dunes can be in three types, one is the cultivated and cultivable, second one is sandy waste and third one is grazing grounds, uneconomic land use, overgrazing and indiscriminate cutting of trees have resulted the increase of desert sand and formation of huge mobile or active sand dunes in many areas, e.g. Phalsund-Pokaran Banyana tract in Jaisalmer district.[7]

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6. Mann, H.S., 1974. Desert spread - analysis in the arid zone of Rajasthan. Ann. Arid zone 13(2): 103-113.

7. Sen, A.K. 1988. Environmental degradation due to desertification in Rajasthan Desert in Desertification, Monitoring and Control Ed. A.K. Tiwari, Sci. Pub. Jodhpur, pp.75-98.

It is noticed that there is a slow progress of sandy materials through luni and sambhar gaps engulfing more fertile land towards the eastern side of Aravallis causing disorganisation of the drainage system and deteriorating adjacent fertile lands. It may be possible that the problem will much more extensive.

TABLE - 1

Land Use of the Sand Dunes

Dune Particular	Land Use	Remarks
1. Stabilized dunes and sandy plain Lower & Middle Flanks	Cultivated	Soil erosion is menace to adjacent land
2. Stabilized dunes lower and middle flanks	Short Fallow	Cultivation should not be practised which may lead to the encroachment of sand in adjacent fertile land
3. Stabilized dunes middle and upper Flanks	Long Fallow	
4. Unstabilized dunes		To be fenced
5. Marginal lands crests	Sandy waste	Recommended for range lands
6. Unstabilized sand dunes	Sandy waste	To be fenced. No Biotic activities.
7. Crests and Upper Flanks of Stabilized dunes.	Sandy Waste	Controlled grazing

Source: A.K. Sen, Environmental Degradation, *Desertification, Monitoring and Control*, p.95.

1.3 **Choice of Study Area**

Since our study is related to Desert Management. It is my purpose to compare the two areas, one of which is most successful in management of Desert as compared to other. So, Israel is the best area where the people of that country made their desert into desert bloom. Other area is India, which is still struggling for the improvement of desert into productive area. Our study area is therefore Negev desert of Israel and Thar desert of India consisting the State of Rajasthan, Haryana, Gujarat and Punjab, which is in the Western part of the country.

1.4 **A Brief Literature Survey**

There are several articles, research papers and books have been published concerning desertification and its control. It contains soil water management, inter-cropping system, and all the resource management, for combating desertification.

The desertification is the process of environmental degradation arising from the fragility of dry land ecosystem and it becomes imperative to heal the ecological wounds of susceptive region by identifying and eventually controlling the factors responsible for depletion. There is a book written on Desertification by Editor A.K. Tiwari[8] in which there is an attempt to an exploration into universal problem of dry lands. It synthesis the theoretical and regional frames of the question of desertification in the Indian dry lands with in-depth analysis of its monitoring, conservation and management.

- Horst G. Mensching and R.C. Sharma[9] - This book is very helpful in the study of desert development in Rajasthan which is part of the desert and this book has some scientific experience in some districts and helpful in knowing the management strategies and future planning of Indian desert. It is the complete book regarding various physiographic and climatic data of Indian desert.

Publication of CAZRI[10] - "Progress in Arid Zone Research Institute 1952-57" - This Institute has in recent past has been entrusted with several exciting task of national importance. CAZRI is thus being called upon more frequently now to play its role in national developmental activities. This publication is very helpful in knowing the CAZRI and its various programme and various management

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8. Tiwari, A.K., 1988. Desertification, Monitoring and Control, Sci. Pub. Jodhpur.

9. Horst G.Mensching and R.C.Sharma 1984. Resource Management in Dry Land, Rajesh Pub., New Delhi.

10. CAZRI Publication, March 1988. "Progress in Arid Zone Research. 1952-1987 Sci. Pub. Jodhpur.

techniques in the desert which is inspired by the CAZRI. J.L. Raina[11] - He has edited the book "Dry land Farming in India" in which there is an effort to present a collective varied perspective on dry land farming in India, which is known as one of the most potent and productive way to combat paucity of agricultural production in arid areas.

In Desertification Control Bulletin H.S. Mann[12] described in his article, "The Revegetation Technologies and Revegetation Programmes in the Indian Desert. L.N.Harsh[13] in his article "Sand due stabilization techniques for arid regions" describes the various methods and approaches for sand dune stabilization. There is special publication of CAZRI on the dry farming technologies. J.C. Tiwari and L.N. Harsh[14] in his article described about the conservational and productive aspects of agro-forestry in Indian arid zone.

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11. Raina, J.L. 1994. "Dryland Farming in India: Constraints and Challenges".

12. Mann, H.S. 1988. Desertification Control Bulletin, No.17, UNEP Pub.

13. Harsh, L.N. 1992 "Sand dume stabilization techniques for arid regions Rehabilitation of Arid Ecosystem. Ed. A.S. Kolarkar, D.C.Joshi and K.D.Sharma. pp.127-135.

14. Tiwari, J.C. and L.N.Harsh. 1987. Tree crop interactions in Agro forestry practices. "Conservational and productive aspect of agro-forestry in Indian arid zone in Environmental Issue and Researches in India pp.305-316.

Similarly the various techniques to combat desertification like technique in amelioration of soils degraded due to irrigation with high residual sodium carbonate/saline water described by D.C. Joshi and techniques regarding sand dune stabilization is described by L.N. Harsh.[15]

M.C.Oswal[16] has done work in rain water conservation, harvesting and its appropriate use in dry land crop production in arid and semi-arid regions.

About the forest tree planting in arid zones, R.N. Kaul and Gyan Chand[17] described it well and made efforts in describing about the techniques according to land use.

Mahander Singh and N.L. Joshi[18] described on the intercropping systems on dry arid environment.

S.S. Parihar[19] described about the soil management for

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15. Harsh, L.N. 1992. "Sand dume stabilization techniques for arid regions" Rehabilitation of arid eco-system Ed.A.S.Kolarkar, D.C.Joshi and K.D. Sharma, pp.127-135.

16. Oswal, M.C. 1994. Annals of Arid Zone 33(2)94-104 (Department of Soil Science, CCS Haryana Agricultural University, Hissar).

17. Kaul, R.N. and Gyan Chand 1966. "Seedlings to progressive spacing, type and time of soil working" Ann. of Arid Zone (5); 25-30.

18. Singh, M. and N.L.Joshi, 1994. "Effect of mixed and intercropping system on dry matter and grain yields of component crops in arid environment" Annuals of Arid Zone 33 (2), 125-128.

19. Parihar, S.S. 1994. "Soil Management for optimizing dry land crop production". Annals of Arid Zone; 33(4); 259-271.

optimizing dry land crop production which is helping article regarding Soil Management. L.D. Ahuja[20] contributes in understanding the management of Range lands in Indian Arid Zone. R.P. Singh and Surendra Singh edited the book "Sustainable Development of the Indian Arid Zone" in which they describe about all the management techniques in almost all the fields in the Indian Arid Zones. Yitzchak Gutterman[21] described about survival mechanism of desert plants in Neger Islands of Israel. By this article, one can understand the different strategies for different plants in the desert. Shanan, L.N.[22] in his article published in Israel journal described the technology efforts in the exploitation of run off from large watersheds. He also describe various techniques for the agriculture in the Negev desert. Daniel Hillel[23] in his book described the whole contents of Neger desert and Israel's desert area including

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20. Ahuja, L.D. 1977. Improving Range Law Productory in Desertification and its Control Ed. P.L.Jaiswal, pp.203-214.

21. Gutterman, Yitzchak. 1982. Survival Mechanism of desert winter. Annual Plants in the Negev Highlands of Israel Sci. Rev. Arid Zone Res.

22. Shanan, L.N., H.Todmor and M.Evenari. The ancient desert agriculture of Negev VII "Exploitation of run off from large watersheds" Israel J.Agr. Res. Ktavim; 9-31.

23. Daniel, H. 1982. Negev, land, water and life in desert environment. Praeger Pub. New York.

various management techniques to know the detail study of the Neger desert of Israel.

1.5 **Relevance of the Study**

The study of desertification and its management is not only our choice but it is a fact that the problem of desertification is acute and there must be some research and development to sort out the problem of desertification. This problem causes imbalance in ecology, which is responsible for low productivity in arid zone. Harsh and unfavourable climatic conditions, wind erosion, poor soils with poor moisture retention capacity are some important problems of arid zones.

It is our scientists' effort that they are able to invent some technologies which are simple and understandable to the poor people of the villages living in the Indian desert.

Desert management includes all the techniques through which the desertification can be stopped. But still after many decades there is going a piecemeal research these must be integrated system approach to increase the standard of living of the people living in desert area, to stabilize the economy and ecosystem of the desert.

Indian desert mainly located in western Rajasthan has been spreading outwards in a great convex arc at the rate of about half a mile per year for last fifty decades. It is matter of great concern regarding this outward spread of desert. Due to this near by States of Rajasthan, like Haryana, southern Madhya Pradesh and Gujarat have been affected. Due to this problem, the agency and research institute like the Central Arid Zone Research Institute has been established so that it can develop technologies, which can be best suited to Indian people and which can improve the productivity and stabilize the ecosystem of arid zone.

This research work compares the Indian situation with Israel's conditions. In Indian context it is important to note that 90 per cent of the cultivated area of the arid zone will continue to be rain fed so it is important to make attempt for more research and development and crop yield per unit of area to be upgraded. But after several years effort the crop yield per unit of area is stabilized. So, it is our compulsion to get break through. On the other side, Israel has made its desert into desert bloom because they have developed their technology that they almost control their desertification. Their comparison with India bring us to some conclusion that capital intensive technology and prevalent environmental conditions bring Israel to combat their desertification problem.

The problem of desertification when compared to Indian situation it is resulted that the Indian technology is different against the technology utilized by the Israelis. Their technology is capital intensive technology. They have money whereas Indian technology is labour-intensive and whatever the technology developmental agencies developed the technology is more relevant to Indian people, but not for total combat of desertification.

There is now more relevance of this research subject because by doing this we can compare the developing country with technically highly developed country.

1.6 Objectives and Motivation

The objective is to investigate the technology used in the Indian desert as well as in the desert of Israel so that we can compare the two situations.

Second objective is to know the traditional technology in desert management which needs to be modified in India, India is a developing country due to less capital it has developed some technology which can be afforded by poor people in arid areas. India have traditional technology we can identify the technology which needs to be replaced by modern one.

Third objective is to know the areas where India needs any transfer of technology. Israel's climatic condition is different and therefore it may be true that whatever technology they develop may not necessarily be fit for India but we can identify the areas which can be developed by utilizing foreign technology.

Fourth objective is to investigate why India is lagging behind in technology acquisition. It is because Indian situation and climatic conditions and standard of living reflects that India cannot afford high tech capital intensive technology.

Fifth to know the various agencies and multi-national organization which are involved in transfer of technology for desert management.

Sixth to know the areas where India needs technological collaboration with Israel.

It is necessary to develop arid zones into productive areas, India is highly populated country and by time the land-man ratio is continuously decreasing one of the factor causing decline in land-man ratio is high population and rapid urbanization put pressure on land and which causes decline in productivity.

1.7 **Research Methodology**

The primary source of the present study is piroting around statistical information and data regarding the magnitude of the desertification, physiographic and climatic data for the comparison or for comparative study. These data are collected from the publication of the United Nations and reports from the Central Arid Zone Research Institute, Jodhpur, publications of the Ministry of Environment, Government of India.

The secondary source of materials are based on the survey of articles of reputed international and national journals, magazines and books. Mainly books and articles have been consulted to study the problem. Vast and detailed study of various articles gave thought process about the subject matter and give inspiration to generate new ideas.

Simple and sophisticated cartographic techniques have also been applied for enormous statistical information to evaluate the spatio-temporal analysis of climatic conditions and magnitude of desertification. Choropleth technique have been used in various maps to give clear ideas of different regions.

1.8 **Scheme of Chapterization**

Introductory part highlights the problem of the study through various dimension, which includes the general problems and definition by various authors, literature survey.

The first chapter deals about the problem as an international problem and its causes then it deals with the relevance of this research work - Objectives and motivation, then Problem of desertification is assessed in Indian context.

The second chapter deals with Arid and semi-arid areas in India and its management in which first described about extent of desertification in India and possible spreading, then progress and achievements in management of arid and semi-arid areas.

The third chapter deals with India's efforts for desert management (includes soil, land, water, agriculture, cropping system, livestock, energy and transfer of technology in India).

The fourth chapter examines Israel's efforts for desert management, in which it describes about the technology used for desert, magnitude and achievement.

The fifth chapter compares the technology inputs for desert management among these two countries - Israel and India, and the success story of Israel and possible collaboration between the two countries for desert management.

CHAPTER - II

ARID AND SEMI-ARID AREAS IN INDIA AND ITS MANAGEMENT

2.1 **Extent of desertification in India**

The great Indian desert forms a part of the Thar desert which extends over Pakistan in the west. The great Indian desert which lies in the north-western part of the country extends approximately between 31°N and 21°N and between 69°E and 76°E comprising an area of about 2,95,000 sq.kms. Indian part of Thar desert extends over parts of Punjab, Haryana, Rajasthan and Gujarat. The area receiving less than 500 mm of annual rainfall has been considered as desert area.

About 62 per cent of the total arid zone in India covering an area of 1,96,150 km^2 lies in western Rajasthan thus forming the principal arid zone in the country. In India arid zone covers about 12 per cent of the country's geographical area (3,20,000 sq km) covering parts of Rajasthan (62 per cent), Gujarat (19 per cent), Punjab and Haryana (9 per cent) and Andhra Pradesh and Karnataka (10 per cent). Apart from this, an area of about 70,300 sq km of cold desert exists in Ladakh in Jammu & Kashmir. The 3/5th of Rajasthan lying west of the Aravallis constitute the bulk of arid zone of the country.[1]

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1. Krishna, Rama. Y.S. 1988. Climatic changes in relation to Desertification in the Indian Arid zone. In Desertification, Monitoring and Control Ed. A.K.Tewari, Sci. Pub., pp.99-113.

The Indian desert extends over a wide latitude covering both peninsular and extra peninsular region. The northern portion of the arid zone is the continuation of the major Afro-Asian hot desertic region and it is regarded that the cold arid tracts of Ladakh located in Himalayan zone depict entirely different biogeographical attributes. Taking into account the manifestation of aridity in the natural setting and ecological features, the core region of the arid tracts of this country including a small extremely arid area and broadly restricted to Rajasthan, Punjab and Haryana. The focal centres for manifestation of desertification are more pronounced in the Rajasthan region, especially in view of the intrinsically desertic nature of this zone. As such, the investigational and implementational activities of various agencies have been to an extent, restricted to the Rajasthan State and its proximal areas.[2]

The area and extent of arid and semi-arid of the arid states of India are shown in table no. - 2:

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2. Jain, J.K. 1988. Desertification in India, extent, causes and control in Desertification, Monitoring and Control Ed. A.K.Tewari Sci. Pub. Jodhpur, pp.-221-223.

Map No. iii

ARID AND SEMI-ARID ZONES OF INDIA

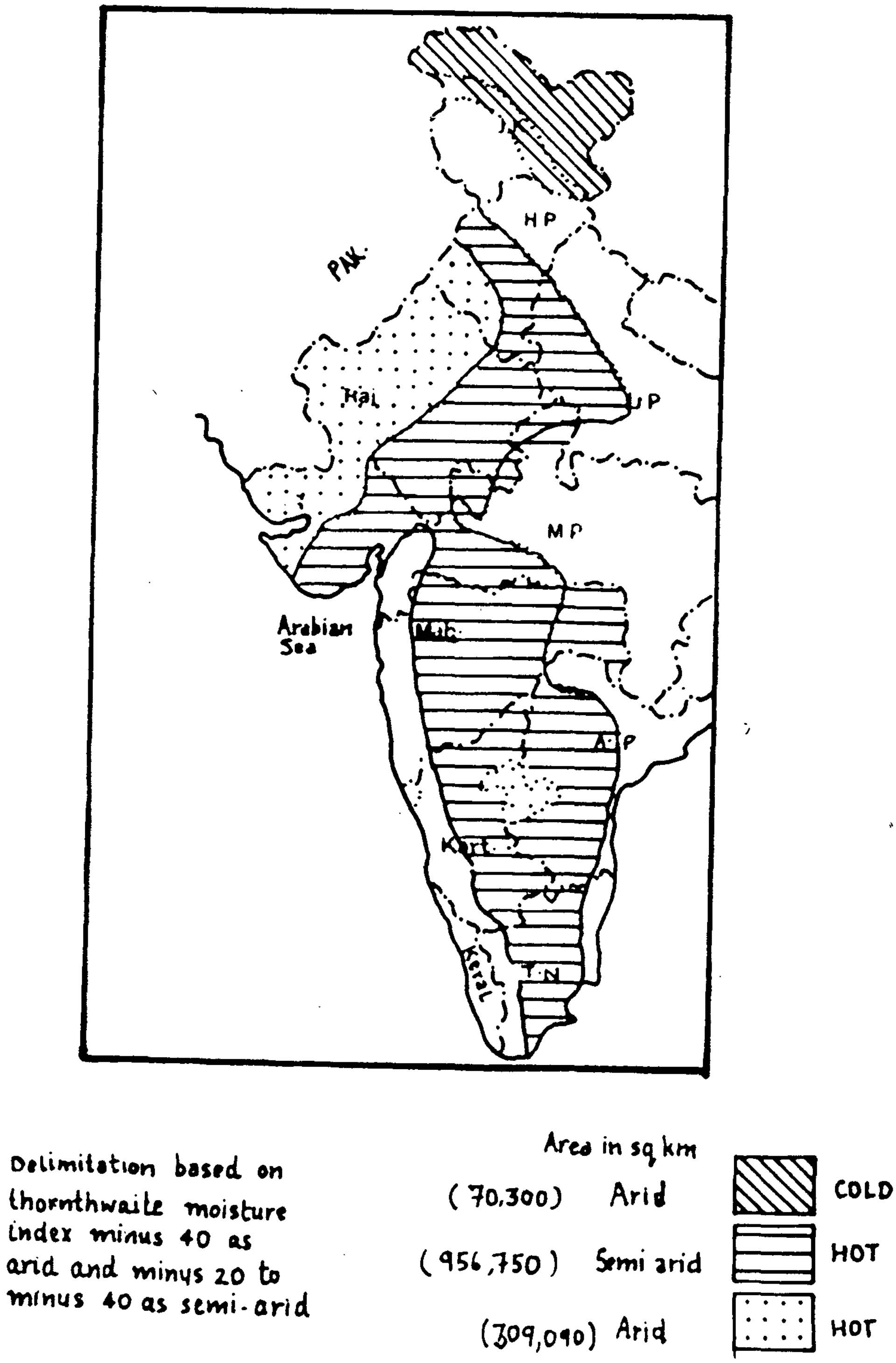

Table No - 2

Showing Extent of Arid and Semi-arid lands of state lands

State	Area (1000 KW^2) Arid	Semi-arid	% area in each State Arid Cold desert	Semi-arid
Jammu & Kashmir	70.3	13.78		
Rajasthan	196.15	120.02	61	13
Gujarat	62.18	90.52	20	9
Punjab	14.51	31.77	5	3
Haryana	12.84	26.18	4	3
U.P.	-	64.23	-	7
M.P.	-	59.47	-	6
Maharashtra	1.29	189.58	0.4	19
Karnataka	8.57	139.36	3	15
Andhra Pradesh	21.55	138.67	6.6	15
Tamil Nadu	-	95.25		10
Total area excluding			-	
Jammu & Kashmir	317.09	956.75		

(The table is from Book `Desertification Monitoring and Control'; p.217).

The area and population of the arid states of India: 1981.

The arid regions of India are having a population of over 25 million with an average density of 74 persons per km^2 as against 4 persons per sq km. in most other deserts of the world. The density of population gradually increases towards east and north-east near the border of Punjab and Uttar Pradesh. There is a broad correlation between aridity and sparseness of population with exceptions in urban industrial clusters like Jodhpur and Bikaner. The distribution and density of population can be expressed in terms of availability and suitability of surface and ground water.

Population density increases where the rainfall increases or the water table approaches the surface. The highest population occurs in the Piedmont belt of the Aravallis all along its western borders and the narrow zone between the Satluj and dry bed of the Ghaggar in the extreme north.[3]

2.2 Spreading of desert and its possible expansion

Spreading of desert - The Indian desert is spreading day by day. This can be revealed by these facts that the causative natural factors of aridity and desertification are the inherent climatic conditions, the geological and geomorphological setting. The rocks are submitted to extreme temperature variations with resultant fragmentation and accumulation detrital sand which are easily transported by raging winds. High evaporation and low precipitation combine to create conditions which facilitates salinization of the entire tract and accumulation of minerals in the ground water and surface water. Soil development is also relatively poor due to shortage of water.

1) Rainfall trends - It is analysed that precipitation records reveals that occurrences of large deficit years are more frequent in the drier part of the arid zone.

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3. Jain, J.K. 1988. Desertification in India, extent, causes and control in <u>Desertification, Monitoring and Control</u> Ed.A.K.Tewari Sci. Pub. Jodhpur pp.221-223.

Incidence of drought years has a multiplier effect on the desertification. There was large deficit rainfall spell during 1962-71 which have significant contribution to the deterioration of the arid zone in India.[4]

2) Dust Storms - The frequency of dust storms rises with reduced precipitation in the preceding year and this is very significant in aggravating erosion and desertification by ultimate removal of soil cover by winds. Measurement of dust during 1973-75 from the surface and 3 meters above, recorded 0.50 to 4.20 quintals per hectare on a dust storm at Jodhpur and 5.11 quintals at Jaisalmer. The removal of grass cover from 2007 sq km caused the depletion of 1065 cubic meters of soil in three years a loss of 0.53 meters of soil depth.[5]

3) Shift of aridity - The variation of aridity reveals shift towards eastward direction from first two decades of the 20th century. Thereafter there were minor to and frooscillations. There is a possible spread of

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4. K.N. 1959. Some studies of rainfall of Rajasthan in particular reference to trends. Ind. J. Meter. Geog. (9) 97-116.

5. Krishna Rama, Y.S. 1988. Climate changes in relation to Desertification in the Indian Arid Zone in <u>Desertification, Monitoring and Control</u> Ed. A.K.Tewari, Sci.Pub. Jodhpur, pp.99-113.

arid condition in the south-east.[6]

4) In adequate organic accumulation in the soils due to the prevalence of climate unfavourable to vegetal growth, soils in eastern tracts of semi-arid zones manifest limited soil profile development, often in ancient stabilised dunes. The relatively richer soils are restricted to the fluvial margings and flood plains.

5) There is disorganization of the drainage, in the Luni and Ghaggar basins and other north-eastern zones, creation of inland basins with ephemeral centripetal drainage, salt lakes and basins and a desert landscape of dunes and other features. As a result, considerable tracts outside the present limits of the arid zone in eastern Rajasthan are stabilised dune fields and it is difficult to recover from these effects.

6) The present configuration of the Aravalli ranges effectively preludes the beneficial influence of the monsoons to a notable extent in the arid tracts of its west and provides the eastern climatic barrier of the zone.

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6. Shankarnarayan, K.A., 1988. Monitoring of desertification in Desertification, Monitoring and Control Ed. A.K.Tewari, Sci. Pub. Jodhpur pp.11-36.

7) The geomorphic setting of the Aravalli ranges have several wind gaps and streams crossing the various blocks. These are potential passage for wind transported material into the outer fringe areas in the direction of the prevailing wind pattern.

8) In a terrain with evaporation in excess of precipitation, the presence of inland basins/ depressions with centripetal drainage and lack of flushing system help in accumulation of the saline material in the entire catchment, one of the major attributes of the desertic areas.

9) The hydrological situation in the tract revealed that aquifers are restricted often with brackish or saline water with boundary condition with deep water tables. Recharge facility are limited due to low precipitation even in the fresh water aquifers. This seriously hampers exploitation possibilities of recuperation of aquifers and maintenance of the ground water regime.

10) Due to a combination of climatic and geomorphic factors, there is hardly any surface water system with integrated drainage and appreciable discharge in this zone for a greater part of the year. The only exception is the Luni and its tributaries, which too is, at present is a misfit system. The extensive salt Ranns

of Kutch into which Luni discharges also contributes to the salinity of the tract.

11) There has been alarming rise in the number of livestock from 10.27 million in 1951 to 16.44 million in 1971, greater than human population. This has led to adverse environmental situation. This result in drastic removal of vegetal cover.

12) Urbanisation and Industrialisation have further aggravate the man-land situation and reduction of forest for fuel and housing.

13) Land use change - Increased population of man and livestock pressure, vast 'area of arid zone have been brought under cultivation often extending to marginal lands also. This include area of stabilised dunes, where farming and removal of roots and stubbles after cropping has led to accelerated wind erosion. Introduction of irrigated agriculture in many areas with adequate drainage measures have also given rise to accumulation of minerals and salt in soil.

All these 13 factors in Indian situation led to desertic condition of the north-western part of India.

Possible Expansion of the Indian Desert -

The possible expansion of the desert over the years has been studied through a series of maps which were prepared on the basis of geomorphic and other physiographic features. The comparison of data (quantitative comparison of economic parameters like land use, water availability, and crop performance between desert areas and bordering regions.

The inherent vulnerability of the land use intense biotic pressure have combined to set in a process of deterioration within the arid zone. About 23,882 sq km of the area in Rajasthan has been affected by desertification hazards. About 4.34 per cent of this area has already been affected by desertification hazards. This part is mostly concentrated in the extreme west in Jaisalmer. The dominant process of desertification here is the expansion of sand covers, dunes, and shifting sand by wind erosion. Other dominant and associated processes are:

a) superficial concentration of stones or desert pavement by deflation; and

b) enlargement of salted or alkalinised area without vegetation, control of hazard is possible by irrigation, shelter belt, wind breaks and sand dune fixation.[7]

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7. Mann, H.S., S.P.Malhotra, J.C.Kalra. 1974. Desert spread. A quantitative analysis in Indian Arid Zone of Rajasthan, Ann. Arid Zone 13(2): 103-113.

About 76.15 per cent of the total area of the desert is high to medium vulnerable to desertification process. Dune, shifting sand, wind erosion are the dominant processes. This area is concentrated along a belt in Ganganagar, Churu, Bikaner, Jaisalmer, Barmer, Jodhpur, Jalore, Jhunjhunu and Nagaur districts. Hazard control is possible here by means of irrigation and fresh water exploitation.

Only 19.50 per cent of the total desert area is subjected to medium to light vulnerable by desertification hazard. The dominant processes are water erosion, enlargement of rock out crops or indurated horizon in surface by water erosion, dunes and shifting sands. This part is mostly along eastern part in a direction of north-east to south-west parallel along the foothill of the Aravallis. Control of hazard is possible by exploiting ground water irrigation and soil conservation measures.[8]

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8. Sen, A.K., H.S.Mann 1977. A geographical appraisals of the expansion and deterioration of Indian desert Ann. Arid Zone 16(3); pp.281-283.

Table No. - 3

Intensity of Desertification

S.No.	Units	Area in sq km	Percent of total area of desertification
Desert and sub-desertic zones			
1.	Desert	9,290	4.35
2.	Arid zone	1,34,552	62.88
3.	Semi-arid zone	66,830	31.25
4.	Sub-humid zone	1,100	0.53
5.	Humid zone	2,210	0.99
	Total	2,13,882	100.00
Natural vulnerability			
1.	Desert	9,290	4.35
2.	High to medium vulnerable	1,62,900	76.15
3.	Medium to slight	41,692	19.50
	Total	2,13,882	100.00
Desertification Hazards			
1.	Desertified area	9,290	4.35
2.	High	1,35,292	63.26
3.	Medium	67,400	31.51
4.	Slight	1,900	0.88
	Total	2,13,882	100.00

(This table is from book - Desertification, Monitoring and Control - A.K. Tiwari).

After considering the geographic and climatic aspects, it is concluded that the Rajasthan desert, which is a part of the great Indian or Thar desert is a true desert having its origin due to the same climatic oscillations during the pleistocene, long after the Himalayas have come into existence which resulted in the formation of middle and low latitude deserts. All studies and evidence suggest that the Rajasthan desert has not, and is not advancing towards east but that fresh sand deposition is still going on and towards the west (within the desert).[9]

2.3 Management of Arid and Semi-arid areas - Progress and Achievement

It is necessary for any country to know and prepare the inventory of the natural resources of the arid and semi-arid region, to develop suitable technologies for optimum utilization of the existing resources, to transfer the technology to the fields.

1. For developmental planning, there has been done special resource surveys, e.g. survey of the upper Luni Basin and on the basis of assessment of resources, suitable management and development strategies for the basin have been suggested. Similarly, resource survey has also been conducted in the Mahendragarh district by Central Arid Zone Research Institute. The land use

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9. Mann, H.S.1977. Desertification, an overview, <u>Ann. Arid Zone 16(3), 1-3.</u>

survey has been done in the district of Churu, Ganganagar and Jaisalmer covering total area of 7,637 sq km. On the basis of survey done, a number of suggestions for overall development of the regions has been made. These include development of recreational and tourism centres in places like Kalibanga, Rangmahal, Anupgarh, Lodarva, Tal and Chhapar etc. Assessments of community needs in settlements around mining sites, traditional crafts centres, silvipastoral and agricultural activity centres, etc. Surveys have also shown the extent to which the present land use is inconsistent with land capacity. About 21 to 24 per cent of the area that is presently being cultivated needs to be brought under permanent cover of grasses and trees.

2. For detailed survey and for regional planning, four atlases of Rajasthan have been prepared on the basis of survey and secondary data.

   1) Agricultural Atlas - consisting of 34 maps

   2) Ground Water Atlas of Rajasthan - consisting of 30 maps

   3) Agro - demographic Atlas of Rajasthan consisting 18 maps

4) Sheep Ecology of Rajasthan - consisting 11 maps.[10]

3. It is possible now to recognise prior drainage system, as these existed before the onset of aridity and their subsequent disorganisation. It has been possible to discover the lost courses of the Vedic river Saraswati, the Luni and the Drishadeveti flowing through the Rajasthan desert. These systems were again tributaries to the Satluj which used to meet the Saraswati at Sirsa, Jakhal, Hammangarh, Anupgarh, etc. Eventually the Saraswati and the Satadru shifted westward and severed their relations.[11]

4. It is possible to cover the land under the cover of natural vegetation by putting mineral inputs. The low level of soil nitrogen is not a serious impediment.

5. The salinization in the flood plains of Ghaggar is found manageable upon the availability of the Canal water. Work done in the Rajasthan Department of Agriculture and Central Water Commission has shown that through leaching and paddy wheat rotation it is possible to reclaim these land.

The Khadin system of land use of Jaisalmer District,

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10. CAZRI Publication, Feb.1988. "Progress in Arid Zone Research, 1952-1987, Jodhpur.

11. CAZRI Publication, Feb.1988. Progress in Arid Zone Research, 1952-1987 Jodhpur.

meant to desalinate the soil through seepage and periodical flushing has been scientifically investigated by CAZRI. Because of the low salinity levels of these depressions the Khadins may prove to be the ideal sites for datepalm cultivation.[12]

6. Use of remote sensing in monitoring temporal changes in areas of saline land and water bodies - It is possible to compare the topograpy of any area. For example, in quantitative term it has been computed that in 1960 an area of 38.12 sq.km was affected by salinity but in 1977 the area affected is about 103.60 sq.km. an increase of about 171 per cent. So it is using of remote sensing which can alarm the situation of any region.[13]

7. Range biomass Estimation by Landsat Data - It has been possible to estimate the range biomass in three soil series that is alluvial soil of younger alluvial plain, chirai soils of sandy undulating alluvial plains and pipar soils of flat alluvial plains. It has been observed that average range biomass yield was the

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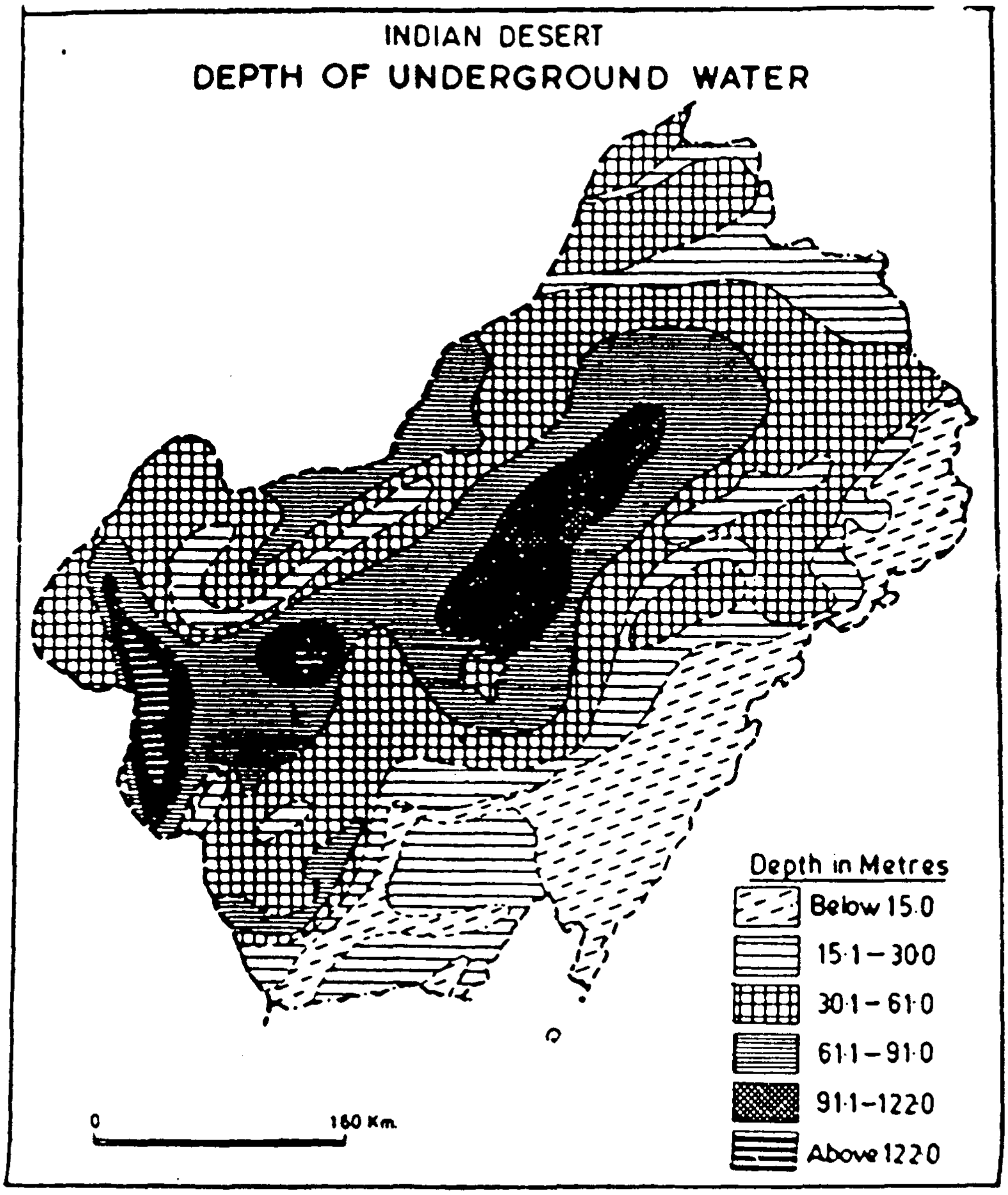
12. CAZRI Publication, Feb.1988. Progress in Arid Zone Research, 1952-1987 Jodhpur.

13. Worcester, B.K., K.J. Dalsted. 1978. Application of Remote Sensing to detection of desertification processes SDSU-RSI J.78.11 pp.1-9.

Map No. iv


INDIAN DESERT
DEPTH OF UNDERGROUND WATER
Depth in Metres
Below 15.0
15.1 – 30.0
30.1 – 61.0
61.1 – 91.0
91.1 – 122.0
Above 122.0
0
160 Km.

highest in alluvial soils (526.8 kg/ha) followed by chirai soil (401.9 kg/ha) and pipas soil (371.2 kg/ha).[14]

8. Hydrological investigations of Jodhpur District revealed 15 new ground water potential zones which covers 2860.19 sq.kms. i.e. 14.5 per cent of district area. These zones have ground water of potable quality and has 282 mcm exploitable annual residual recharge and 1002 mcm exploitable storage potential. There has been over exploitation of ground water from presently exploitable zone and it is require to restrict the further exploitation of ground water from these zones and advise management practice be adopted.[15]

Similarly, 14 new ground water potential zones have been identified in Nagaur District, which are situated in blownsand, older alluvium sandstone, limestone and phyllite acquifer. The new method has been developed and applied to Nagaur District known as Index Catchment Studies and which will be applicable to the areas having no defined drainage system like Nagaur District is know the water balance of the area.

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14. CAZRI Publication. Feb.1988. Progress in Indian Arid Research Zone, 1952-1987, Jodhpur.

15. CAZRI Publication. Feb.1988. Progress in Indian Arid Research Zone, 1952-1987, Jodhpur.

9. Afforestation techniques is now used to curbing the spread of desertic conditions. There is wind breaks and shelters belts established to provide mechanical obstacles to the fre sweep of wind in order to reduce its velocity. Such obstacles, besides reducing wind velocity and soil erosion reduces evaporation from the soil also minimising the desiccating effect of the wind.[16]

10. Three basic techniques are applying for sand dune stabilisation which is another important measure. These three techniques are: (1) Protection against biotic interference by fencing of the area, (2) establishment of micro windbreaks on wind ward side of a dune in 5 m parallel strips or in a 5 m chess board pattern, (3) sowing of grasses and transplanting of adapted tree and shrub species raised in earthern bricks on the leeward side of the micro wind breaks.[17]

11. There is introduction of fast growing tree species. In this effort 112 Eucalyptus species, 65 Acacia species and 82 miscellaneous ones from various countries

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16. Bhimaya, C.P. and R.N.Kaul. 1960. Some affforestation problems and research needs in relation to erosion control in arid & semi arid parts of Rajasthan. Indian For, 86 pp.453-468.

17. Harsh, L.N. 1992. Sand dune stabilization techniques for arid regions in Rehabilitration of Arid Eco-system Ed. A.S.Kolarkar, D.C.Joshi & K.D.Sharma. Sci.Pub. Jodhpur, pp.127-135.

including Mexico, USA, Latin America, USSR, Africa, Israel, were introduced. *Eucalyptus comaldulensis, E terminals, E melano pholia, Acacia fortills, A. raddiana, A. seyal, A sieberiana A. aneura, Colophospermummopane, Dichrostachys glomerata, Brasiletta mollis, Schinusmolis and Prosopsjulflora* have emerged very promising for Indian arid zone. *Acacia tortilis* has been adjudged the best fuel cum fodder species for our dry zones.

Soil working technique and cultural methods suitable for establishment of plantations in different land types have been developed. Prospopis julifora, Tamarix articulate, Acacia tortills and chenopodium species are tolerent to saline conditions.[18]

12. The Indian scientists tried to identify the suitable dry land crops and their varieties which match the rainfall pattern of the region and are efficient utilisers of rainfall and stored soil moisture have been identified such as Bajra-BJ104, Moong S-8, moth T-18, T-23, Cowpeas FS 68, til T-13, castor aruna; BAJCH-1, Bhaggya; sunflower-EC 68414, gaur Durgapura safed FS 277; Durgajai HFG-75, 2470/12).

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18. CAZRI Publication. Feb.1988. Progress in Indian Arid Research Zone, 1952-1987, Jodhpur.

India has developed strategy to meet the aberrant weather situation suitable and remunerative cropping systems, including inter-cropping systems have been identified and it is possible to follow a double crop system i.e. Bajra BJ 104, mustard T59 on dry lands if rainfall is good to some extent.

All types of techniques like securing proper and adequate crop, pre-sowing seed treatment (soaking of seed in water) for hard coated seed like sunflower, castor, optimum seeding depth, etc.[19]

Preparation of seed beds with a sweep cultivator was found to be expeditious and efficient with regard to weed control.

Field bunding has given efficient result in about 36 per cent more conservation of moisture helps in yield. The achievement is tremendous in water harvesting technique. Integration of hybrid bajra, fertilizer use and better crop husbandry (one shallow tillage on weeding double row planting geometry and rotative cropping into the system of micro catchment farming) brought the yield level of bajra crop from 3.2

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19. Singh, R.P. 1987 Dry Farming technologies for the North-Western Arid Zone of India. AICRP, Hydrabad. Paper 52.

q/ha the usual average yield from the local practices to 27.6 q/ha.

13. The run off collection from a bare catchment revealed the possibilities of recycling the stored run off for giving (a) life saving irrigation to bajra during prolonged drought in the season, (b) as supplemental irrigation to long duration crops like castor and golar beans at the later stage of growth, (c) pre-sowing irrigation for crops during subsequent winter season.

14. There is use of sub-surface water barriers for water and nutrient conservation and Bentonite clay which is natural resource of western Rajasthan as sub-surface moisture barrier, it helps to reduce deep percolation of moisture from the root zone. Partial incorporation of bentonite in pits or trenches when integrated into run off concentration technology has made possible the production of vegetable crops like tinda and bhindi in dryland conditions.[20]

15. Higher moisture loss during the summer can be substantial. Polyethelene mulch was found to conserve more moisture than organic mulches like grass and bajra straw, etc. Polyethylene mulch raised the thermal

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20. CAZRI Publication. Feb.1988. Progress in Arid Zone Research. 1952-1987. Jodhpur.

status of soil while grass mulch lowered it. Polyethelene mulch gave the highest production of pearl millet followed by grass, bajra straw and control.

16. Soil management - The use of bentonite clay and exfoliated vermiculite at the rate of 20-40 t/ha has been found to increase moisture retention at 0.1 bar tension, lower soil temperature by 1 to 5°C and thereby helps in the increase of production of Bhindi.

The use of pond sediments at the rate of 76 t/ha improved the moisture retention and fertility of Loamy sand soil and thus raised the production of pearl millet and green gram.

Use of both bentonite clay and pond sediments increased the mineralisation rate and mineralisation potential of Loamy sand soil which contributed towards the crop productivity.

The use of farm yard manure along with urea in 1:3 ratio to supply 80 kg n/ha was found to increase moisture retention in soil, lower the compaction level and thus increase the production of pearl milet.

17. New cropping and irrigation technique invented according to properties of soil particularly eateral water transmission characteristics of the sub-soil (30-50 cm) depths. The technique consists of growing of two

different crops of rabi i.e. wheat and soya sown parallel having diverse physiological and myrphological characteristics such as water requirement, salinity tolerance and root systems. One is irrigated principal crop (wheat) and other is unirrigated crop (raya) the transgress of soil moisture from irrigated wheat rootzone into unirrigated rootzone of raya which eventually benefit raya crop. The low water requirement, higher tolerance to salinity and deeper root system of raya make it an ideal intercrop under this technique.

This is the strategy which serve as an ideal system of cropping under scarce water situation like western Rajasthan where irrigation water are saline too.[21]

18. In horticulture India adoapted various fruit plants to different agro-climatic conditions. Number of improved varieties of ber such as seb, Gola and Mundia, have been selected. Gola is early maturing. The new technology developed in India's Arid Institute has reduced the time from one year period required for raising a ber orchard to only 4 months.

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21. CAZRI Publication, Feb.1988. Progress in Arid Research Zone. 1952-1987, Jodhpur.

19. By simple enclosure, forage from rangelands could be doubled in about three years time. Fertilization with 22.5 kg N/ha resulted in additional increase in forage yield 20 to 70 per cent. Animal huysbandry plays an important role in the economy of desert areas. The Indian scientist in various institute experimented with in various breed which gives more income to farmers of the arid region. Various new breeds have been developed which is useful for desert conditions.[22]

20. Various plants in the deserts have been exploited for economic purposes e.g. Diosgenin and Hyoscine. Similarly Candelilla wax produced wax which is suitable for end-use in manufacture of explosives.

21. Achievement in energy sector is that research efforts has developed appropriate technology for utilization of solar energy for water heating, cooking, desalination drying of agricultural produces, and pumping water and for generation of electricity.[23]

22. Indira Gandhi canal project has been constructed in two stages in the north western part of Rajasthan covering

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22. Ahiya, L.D. 1987. Management of Rangeland in Indian Arid Zone in Sustainable development of Indian Arid Zone Ed.R.P.Singh & Surender Singh. Sci. Pub. Jodhpur.

23. Garg, H.P. and Kanishka. Solar and wind energy utilization Desert Resource & Tech. I (1982) pp.179-213.

the Thar desert, making the Bikaner and Jaisalmer districts into one of the potential area of crop production. Canal is constructed in two stages i.e 204 kms long-feeder, 189 km long main canal, 3,123 km of distribution system, 5 flow branches and one lift canal in Ist stage. It is in progress including 189th km main canal to 445 km and distribution system having a length of 5,209 km. This stage has 5 flow branches and 5 lift schemes. This stage would cover a canal command area of 10,95,00 ha. at 86 percent intensity of irrigation.

The irrigation in hot arid land of western Rajasthan through Indira Gandhi Canal particularly in the districts of Ganganagar, Bikaner, Jaisalmer and Barmer has improved the micro-climatic conditions. It has resulted in minimising the dedicating effects of temperature and strong winds strong winds on bio mass production and settlements. In other words the harsh and inhospitable climate of these regions has become milder and favourable for growth of plants and raising of habitation.

The sandy hummocks and low dunes have been levelled and reclaimed for growing cereals, pulses, some cash crops (like cotton, groundnut) and vegetables. The moisture regime with in the soil, after the irrigation has improved and their erodability has decreased. These tremendous changes have also influenced the fertility status of the soil particularly in Bikaner & Jaisalmer districts.

In Ganganagar and north western parts of Bikaner canal command district, water resource are easily available and farmers in this region purchased tractors and using mechanised farm techniques. There is rising trend of ground water table at the rate of 0.8 meter per year.[24]b

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24. Ansari, Ajza Hussain and Shahid Imam, 1996 Ecological Impact of Indira Gandhi Canal Project in Western Rajasthan, Kurukshetra, Vol. XLIV, No.6, March 1996.

CHAPTER - III

TECHNOLOGY TRANSFER EFFORTS & DESERT MANAGEMENT IN INDIA

The present chapter looks into the efforts made in the field of technology transfer in India for desert management. It has been observed that apart from the transfer of technology numerous scientific approaches and techniques have been evolved to address the problem of sustainable utilisation of desert resources and their management. These approaches and techniques have been found of great importance in the process of desert management espeically when the process of desertification has started showing its implications.

In the following paras, management of soil and land, water, Agriculture and cropping system, and livestock has been discussed seperately at the end of the chapter problems and issues involved in the process of technology transfer and diffusion of such information have been discussed.

3.1 Technology Efforts in Management of Soil and Land

It is soil (sandy-structureless top soil), climate (low rainfall high wind velocity) and vegetation (sparse vegetative cover) factors that are responsible for wind erosion in the Indian Arid Zone. In soil factor the variation is from sand dune, through grey brown desert soil to finer textured alluvial soils. The technique for the management of sand dunes has been developed at the Central Arid Zone Research Institute and is being extensively being used by the Department of Afforestation and Pasture Development, Jodhpur, for stabilizing the dunes in the Indian desert. Fine textured soils are of common occurrence and are confined to pockets. Such areas, in general, are irrigated. Thus soil-wise the problem is particularly confined to loamy sands and to some extent, sand loams in the grey desert soil areas.

It is primarily the rainfall factor on which the control measures for wind erosion should be based the variation in the annual average rainfall in the region being fairly large, ranging from less than 100 mm to more than 400 mm. Moreover, overall agrarian management of the region viz. crop production, afforestation and grassland development which encompasses various control measures, is also based on rainfall, its amount and distribution.[1]

In general, the approach to control wind erosion is two-fold:

A. Protect the soil from wind erosion.

B. Create a soil condition resistant to wind action.

In this context, measures that have been developed are as follows:

1. Afforestation, shelter belts and wind breaks.

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1. H.P. Singh, Soil Management in the Indian Arid Zone. Sustainable Development of the Indian Arid Zone. Ed. R.P. Singh and Surender Singh.

2. Grassland development.

3. Wind strip-cropping.

4. Stubble mulching

5. Tillage.

   a) Proper equipment

   b) Minimum tillage

   c) Set row cultivation

   d) Emergency tillage

   e) Cloddy fallows

Except the tillage, all the above measures fall under the first approach i.e. protecting the soil against wind action. Vegetation like grasses apart from reducing the contact between wind and soil, also help in stabilizing the soil in a long run due to the binding action of their root network, application of FYM, pond sediments and various soil conditioners etc. would help to reduce the wind erosion hazard, in a long run.[2]

General Control Measures

1. Shelter belt plantation - Shelter belt plantation is common to all rainfall conditions. The choice of tree

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2. Chepil, W.C. and N.P. Woodruff, 1963. The Physics of Wind Erosion and Its Control, <u>Adv. in Agronomy</u>, 15, 211-302.

species in the belt would however depend upon the particular soil-climatic conditions. Similarly the thickness and shape of the belt would be governed by the intensity of the problem in a particular area. A five row shelter belt with a pyramidal shape was recommended for those areas where wind direction at times undergoes an abrupt change. The tree/shrub species that have been recommended for shelter belt plantation are *Prosopis juliflora, Azadirachta indica, Albizzia lebbok, Acacia tortilis, Tamarix articulata, Acacia senegal, Parkinsonia Aerua tomentosa, Zizyphus spinachristi and Calligonum polygonoides.*[3]

2. Plantation of trees and grasses on marginal and sub-marginal lands - Erosion from such areas has its serious repercussions in adjoining, relatively productive areas. Irrespective of rainfall distribution, such areas, instead of crop production, be used for tree plantation and grassland development.[4]

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3. Zingg, A.W. and White C.J. Field , 1957. A Summary of Research Experience with stubble-mulch Farming in the Western State. U.S. Department of Agriculture Technology Bulletin. 1186 to 1657.

4. Hopkins, E.S. 1937, Soil Drift Control, Canada Department of Agriculture, Publ. 569.

Site Specific Measures

1. Less than 200 mm rainfall zone (Jaisalmer, part of Barmer)

    a) Grass land development

    b) Afforestation

2. 200-300 mm rainfall zone (Part of Barmer, Bikaner)

    a) Afforestation and agroforestry

    b) Grass land development, silvi pasture

    c) Wind strip cropping of legumes with grasses (on field to field basis).

Strip cropping is a practice under which strips of erosion resistant crops, i.e. grasses and legumes are planted between the strips of erosion susceptible crop like pearl millet strips are oriented as nearly as possible at right angles to the prevailing wind direction.

3. 300-400 mm rainfall zone (Jodhpur, parts of Nagpur, Jalor Pali)

    a) Agroforestry and pasture development

    b) Wind strip cropping, grass-legume cereal (Pearl millet) system.

    c) Minimum and proper tillage set now ridge/furrow cultivation Minimum and proper tillage with proper production is practised in such areas.

With a view to both, minimising tillage and at the same time ensuring proper seed bed preparation, a technique of ridge furrow cultivation has been developed at the CAZRI, Jodhpur (Singh and Bhatti, 1988). Under this technique crops are planted in pairs in the furrow (30-40 cm) alternated by ridge inter-space (60-70 cm). Tillage is performed in the furrow and inter-pair space (ridges) left permanently unfilled. The tillage component is thus reduced by 60-70 per cent. Besides reduction in tillage, the ridges act as barriers against the processes of saltation and surface creep.[5]

4. More than 400 mm rainfall areas (Churu, Jhunjhunu, Sikar and parts of Pali and Nagpur).

   a) Agroforestry and silvi pasture development

   b) Strip cropping (cereal-legume)

   c) Optimum tillage - set row cultivation

   d) Stubble mulching.

   Stubble mulching - leaving the crop stubbles in the field and planting the next crop without disturbing the stubbles was developed as early as 1910. Since then it

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5. Singh, H.P. and T.K. Bhatti, 1988. Ridge Furrow System of Planting Dryland Crops for Soil and Rainwater Management in the Indian Arid Zone. Int. Conf. Dryland Frmg., Texas, USA, Abstr. p. 41.

has proved an effective method both, for moisture conservation (more infiltration, less run off) and control of wind erosion in drought prone arid areas. The practice resulted in 6 per cent higher grain yield of the next crop.

The basic function of crop stubbles on the soil surface is to reduce the force of wind on soil wind action on soil surface could be eliminated to the extent of 5 to 99 per cent by different kind and amount of crop stubbles. Besides the stubbles trap the saltation particles and break the chain of saltation phenomenon.[6]

5. Irrigated areas (viz. Ganganagar, parts of Bikaner Districts, etc.) In irrigated areas, if no crops are grown during summer months stubbles of rabi harvest can be left in the field. This would reduce wind erosion hazards on one hand, and ensure the recycling of organic residue on the other hand.

These are the practices that can be helpful in practising conservation farming in different agro-climatic conditions of arid areas prone to wind erosion hazards.

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6. Mann, H.S. 1980. Soil Erosion and Sand Movement Technologies for Control. Paper Presented at FAO/DANIDA Training Course on Sand Dune Stabilization, Shelterbelt and Aforestation in the Dry Zones. CAZRI, Jodhpur.

Growing of trees and crops together is the ideal system for soil and water conservation in the arid zone. The trees, provide the much needed permanent cover to the land surface which is the basic requirement for control of wind erosion. This is revealed by the CAZRI, Jodhpur.[7]

3.1.1. Soil Fertility Management

Soil fertility is the function of physical, chemical and biological processes and their interactions taking place in the soil medium. Under arid conditions all these three categories of processes are considerably slowed down due to paucity of water. Soil fertility varies, depending upon the processes of soil removal and deposition. The general status of soil fertility is that soil organic matter and Nitrogen is low due to scanty residue addition and improper decomposition. (Organic matter 0.2 to 0.4%) and nitrogen (80-250 kg/ha). Phosphorus is however in the low to medium range (6-8 ppm). The status of Potassium falls in the high range, both with respect to total (0.07 to 1%) and available (250-500 kg/ha) potassium.

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7. Mishra, D.K. 1964. Agronomic investigations in arid zone. Proc. Symp. Problem of Indian Arid Zone. Ministry of Education, Government of India, New Delhi and UNESCO, pp. 165-169.

One of the important sources of soil nitrogen is the rain water. Efforts have been made to quantify this phenomenon in the Indian Arid Zone. (Aggarwal et al. 1980). It was estimated that the annual addition of Nitrogen for normal rainfall conditions ranged from 5.2 kg/ha at Jodhpur to 13.4 kg/ha at Pali. The atmospheric dust resulting from wind erosion was felt to be the main source of this nitrogen.[8]

Fertility Management

The factors responsible for low fertility of the arid zone soils, can be placed in two categories: (a) Natural-inherent and (b) Faulty management. There is requirement of integrated approach to soil fertility management. This approach has following components:

1. Residue/Soil organic matter management.

    a) Incorporation of grasses in production system - By this soil stability is increased in a long run. At the same time, relatively larger quantities of underground biomass is added to the soil. This helps in building up the soils organic matter status in a long run. Marginal and sub-marginal

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8. Aggarwal, R.K. and V.K. Sharma, 1980. Availability of nitrogen and phosphorous during the decomposition of Calotropis procera (AR) in the desert sandy soil. J. Indian Soc. Soil Sci. 28, 407-409.

lands if put under grasses would eventually be fit for crop production in the course of time strip/inter-cropping with grasses and rotation of grass and crop strips every 8 to 10 years, would be useful both with respect to stability in production and maintenance of soil organic matter.

b) Incorporation of organic matter (vegetable wastes) - Incorporation of chopped (Calotropis procera) plants in the soil (15-20 cm depth) increased the soil moisture storage capacity, availability of P and crop-yields. Application of dried and powdered (Calotropis procera) plants increased the availability of both nitrogen and phosphorus.[9]

c) Incorporation of organic manures - Application of FYM @ 40 t/ha once in two years resulted in significantly higher yield of pearl millet in all the five years, 1975 to 1979. There was a build up in soil organic matter level (60-100%) over the five years period.[10]

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9. Aggarwal, R.K., A.N. Lahiri, and P. Kaul, 1980. The accession of nitrogen through rain water in arid areas of western Rajasthan. Proc. Nat. Aca. Sci. India, Vol. 50(A), II, 64-68.

10. Singh, R.P. H.S. Daulay, K.C. Singh, and B.S. Gupta, 1978 Effects of Rates and methods of nitrogen application on yields and yield attributes of rainfed bajra HB3 grown in arid areas. Ann. Arid Zone 17(2); 136-144.

d) Incorporation of Pond sediments - Ponds locally known as *nadis* are fairly abundant in the arid zone. The pond sediment besides being rich in the clay fraction contain high amount (1.4%) of organic matter. Thus it improves fertility indirectly that is by increasing the moisture storage capacity, the sediments may have direct effect on the soil fertility status.[11]

2. Improved Cropping/Planting System

a) Crop rotation - Bajra (Pearl millet) is one of the most important crops of the arid zone. It has been observed that this crop simply does not perform well if grown in the same field even the following year. As such, it has to be rotated preferably with legumes like green gram, dewgram, clusterbean and cow pea, etc. and it has been resulted that saving to the extent of 20 kg N/ha in the fertilizer use can be effected by growing pearl millet in rotation with green gram instead of

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11. Aggarwal, R.K., J.P. Gupta, and P. Kaul, 1980. Nitrogen mineralization as affected by addition of Pond sediments and bentonite clay to a sandy soil under different moisture regime, Indian Soc. Soil Sci. 28(4), 444-449.

continuous cropping of Pearl millet.[12]

b) Inter-cropping system - bring stability in production by more efficient moisture use and minimising the risk of crop failure, but also contribute in the management of soil fertility as well.

c) Ridge furrow - fixed row cultivation - Under this system tillage is performed and planting done in the permanent set furrows (30-40 cm) and the inter-set spaces i.e. ridge (60-70 cm) left untilled. The fertilizers and manures are applied in furrows only. The fertility management thus can be restricted to 30 to 40 per cent of the field area. This would sufficiently reduce the quantities of various inputs required to maintain and build up of the soil fertility.[13]

d) Weed control - Weeds take away considerable quantities of plant nutrients. Unless the weeds are recycled back to the soil, these nutrients are as good as lost permanently. Hence judicious weed

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12. Singh, R.P., H.P. Singh, H.S. Daulay, and K.C. Singh,1981. Fertilization of Rainfed greengram pearl-millet sequence. Indian J. Agric. Sci. 51 (7): 498-503.

13. Singh, H.P. and T.K. Bhatti, 1988. Ridge furrow system of planting dryland crops for soil and rainwater management in the Indian Arid Zone. Abstr. Int. Conf. Dryland. Fmg. Texas, p. 41.

control management is important for the efficient conservation of soil fertility.

3. Efficient Fertilizer Use.

a) Nitrogen - Application of 40 kg N/ha has been found to be optimum for pearlmillet crop in normal rainfall situation. Application of 10 t FYM + 10 kg N/ha, gave consistently good results. For sesamum, the optimum N requirement was 30 kg/ha under normal rainfall and 60 kg/ha under good rainfall situations. Splitting of N dose into 2 or 3 splits at sowing, tillering and grain development, has been recommended. Urea sulphur ratio of 8:1 and 6:1 have been found adequate for cereals and oil seed crops, respectively.[14]

b) Phosphorus and Potassium - Application of P may not be necessary to each and every crop in the long range cropping system. Hence phosphorous fertilization practice should be worked out for the whole cropping system rather than individual crop in dry lands.

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14. Aggarwal, R.K. and P. Kaul, 1978. Loss of nitrogen as ammonia volatization from urea on loamy sand soil of Jodhpur. Ann. Arid Zone 17(2), 242-245.

So these approaches need to be applied in an integrated manner for the maintenance and build up of soil fertility in the arid zone.

3.1.2. <u>Management of Land</u>

In this, we can classify the land management in which efforts are being done.

1. Land use (management)
2. Management of Range lands
3. Management of the rainfed lands
4. Improvement in grasses
5. Afforestation and social forestry
6. Sand-dune stabilization.

1. <u>Land Use Management</u> - Assessment of use and misuse of land is pre-requisite for planning of the utilization of resources. Land utilization survey and mapping is the obvious requirement to make such estimates. A land use map shows the distribution and extent of different lands. The level on which the different landuse classes are classified and cartographed is based on the type of survey undertaken, viz., reconnaissance, detail reconnaissance or detail. It also depends on the material data and information available. A land use map tends to evaluate the lands actually used on one hand and also the lands available for further use on

the other. The map is helpful in predicting the use and misuse of land and to recommend its suitability for better use like farming, forestry, pastures, settlements, etc. under different systems of management.

Hence the ultimate purpose of land utilization survey and mapping is to arrive at systems of land use and management best suited to the kind of resources and capabilities of land. In India there are land use maps which are based on survey and remote sensing techniques. Efforts is also successful in field survey techniques. Maps are prepared in 1:250,000; 1:100,000 to 1:50,000 and 1:15,000. Problems of arid zone are depicted in maps by doing land-use surveys. Intensity of cultivation can also be drawn by land use surveys and then region can be divided into agro-ecological regions.[15]

2. Management of Range Lands - Land utilisation pattern in arid regions of Rajasthan reveals that area under cultivation is higher 61.3% in zone where average annual precpitation is 300 mm and above. While it is

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15. Sen, A.K. 1977. Land use mapping of arid zone by areal photo- interpretation techniques. In Desert Ecosystem and Its Improvement (ed. H.S. mann) pp. 85-100.

31.4% where any annual rainfall is below 300 mm.[16] In District Jaisalmer (with annual rainfall below 200 mm), the area under cultivation during normal years of rainfall is about 5 per cent. Hence most of the uncropped land is mainly grassland which is a source of livestock production for local economy. There is a shortage of forage for existing livestock population amounts to 35.1 per cent in total and zone. So situation is alarming during years of scarcity.

Average aridity index of arid zone in north-western region of India is 78 per cent with 91 per cent in Jaisalmer[17]. Hence, livestock farming, is one oof the mainstay of local population which gets its sustenance mostly from rangelands. Rangeland may be defined by Ahuja, L.D. as a landform where agriculture cannot be sustained on sound footings due to hostile agro-climatic conditions. Forage yield could be substantially increased if existing "poor rangelands are improved and brought under good and excellent condition class. Classes of rangelands in arid regions and their carrying capacity is depicted in table 5.

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16. Ahuja, L.D. and H.S. Mann, 1975. Rangeland development and management in Western Rajasthan, <u>Ann. Arid Zone</u> 14(1) 29-44.

17. Krishnan, A. 1968 - Delineation of different climatic zones in Rajasthan and their variability. <u>Ind J. Geog.</u> 3; 33-40.

Techniques of improving rangelands - There are techniques wahich are suitable for Indian situation. The following are techniques:

a) Selection of sites

b) Fencing

c) Grubbing of unwanted bushes

d) Top feed cum shade trees on rangelands

e) Stabilization of sand dunes

f) Reseeding grasslands

g) Rodent control

h) Preservation of forage

a) It will be desirable to take up grassland development work with the start in areas with easy accessibility and water facility so that local people can visit the places frequently and realise the value of such developmental works.

b) Fencing is essential due to heavy livestock pressure. One with barbed wire and angle iron posts was, by far the most effective and economical in the long run.[18]

c) Unwanted thorny plants like *Lycium barbarum, Balanites acgyptiaca, Acacia Lencophloea, Mimosa*

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18. Ahuja, L.D. and H.S. Mann, 1975. Rangeland development and management of western Rajasthan. Ann. Arid Zone 14(1) 29-44.

hamata etc. which hinder the growth of grass species and are troublesome to grazing animals should be grubbed out mechanically followed by application of herbicide 2,4,5-T (trichlosophenoxy-acetic acid) immediately after cutting away aerial parts of bushes, with protection and grazing, the native rangelands on the carrying capacity, aiming 70 per cent forage utilisation level, forage yield increased and practically double in 2 to 3 years time.

d) Trees provide top feed, shade to grazing animals and timber, thorny material for fencing and fuel on the range. Top feed in the form of leaves and pods (rich in proteins and minerals) provide valuable nutrition to the livestock during lean periods of the year, thereby increasing the secondary productivity. Suitable top feed species could be planted along the boundaries,[19] inspection paths and approach roads of compartments of the rangelands in single or double rows. They act as wind breaks and shelter belts. Species like

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19. Ahuja, L.D.1977. Grassland & Range Management in Desert Ecosystem and its Improvement (Ed.H.S. Mann); pp.296-322.

Acacia nilotica and Prosopis juliflora grow well on mounds of corewall fencing to provide additional protection.

e) For stabilization and rehabilitation of sand dunes, four distinct process are involved : a) protection, b) mulching, c) afforestation and d) planting of seedlings or root slips of drought hardy perennial tussochy grass species.[20]

f) Reseeding of grasslands involves selection of suitable species for reseeding in different tracts like *Dichanthium annulatum* which gives high yields. Reseeding involve proper soil working, sowing of appropriate grass species and after care of the resultant cover,[21] pelleting of seeds of *Lasiurus sindicus* with cow dung, tank silt or clay and sand in proportion of 1:1:3:1 using sufficient quantity of water for preparing round pellets.

g) Among the various poisons to kill rodents pests tried, Zinc phosphide and compound 1080, monofluro acetate have proved to be efficacious.

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20. Mathana, K.D. and Ahuja, L.D. 1973. Sand dunes, the way to stabilize and manage. Ind. Fmg.XXIII(3); 25-29.

21. Ahuja, L.D. 1977. Improving Rangeland Productivity In Desertification and its control. (Ed. PL Jaiswal). pp.203-214.

h) Forage can be preserved as i) silage ii) hay. As losses in silage making in fermentation etc. and at final stage are quite high, hay making in arid regions is the only recourse presently. On range-lands, perennial grass species, e,g, *Lasiurus sindicus* (sewan), *Cenchrus* (Dhaman), *Dichanthium annulatum* (Karad), *Panicum antidotale* (Gramna) are recommended. Cultivated fodders like sorghum, pearl millet, maize, hybrid napier, besseem, cow pea form a good hay.

3.1.3 Management of Rainfed Lands

Moisture conservation and efficient utilisation of precipitation and stored soil moisture hold the key to judicious management of rainfed lands.

a) Increasing water storage - In the root zone constitutes the major objective of any water conservation practice. The solum has to be recognised as a moisture reservoir of great consequence, particularly in arid regions, where precipitation ois the major limiting factor in crop production. Water that infiltrates into this reservoir can be stored with relatively little loss for fairly long periods, longer than is generally realised.

i) Reducing Run Off - Strap cropping, contour ploughing are the measures that lead to run off control. In fact, vegetation is one single factor of major consequence in runoff control. Plant cover in watersheds is guarded against soil erosion.

ii) Increasing Infiltration - Mulches, either straw or crop residues, markedly improve infiltration, besides reducing runoff, thereby contributing to increased moisture storage in the solum.

b) Water Harvesting - In dry regions like in Rajasthan, Gujarat,Haryana, etc., the rainfall received during the crop season is not adequate to ensure a crop, harvested water plus that stored in the soil profile will suffice for ensuring a crop. Preparation of micro-watersheds, conservation bench terraces are other versions of water harvesting procedures.

c) <u>Reducing Evaporation Losses</u> - It is also for conserving moisture for longer period. Straw and stubble mulches and chemical treatments are now available for reducing evaporation losses from soil.

d) <u>Internal Water Balance</u> - It helps in growth and development of plant which indirectly related to soil moisture conditions.

e) A deep root system capable of tapping moisture from deeper layers of soil profile contributes to best crop varieties for rainfed lands. Bajra (pearl millet) has been found to be the most efficent crop in normal rainfall years (around 360 mm). In good rainfall years (>500 mm) even Sorghum (CSH-1) exhibited high yield potential thereby providing diversification to the cereal based economy of drylands of Rajasthan.[22] Moisture use efficiency (MUE) of bajra hybrid (HB 3 and J 41) was found to be 8 to 9 kg grains/mm of water against 4.8 kg grains/mm in case of the local improved variety, Mungbean s-8 gave an yield of 10 to 12 q/ha in 60 to 65 days, variety FS 68 of cow peas, possessing a compact plant type, maturing in 65 to 70 days, with an yield potential of 9 to 12 q/ha is a promising variety of this tract (Western Rajasthan).[23]

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22. Mann, H.S. and R.P.Singh, 1977. Crop Production in India Arid Zone - In Desertification and its Control. (Ed. P.L. Jaisalmer): ICAR - pp.215-224.

23. Daulay, H.S.; R.P. Singh, and K.C. Singh, 1978. Studies on the Relative Efficiency of Bajra and Mung varieties in utilizing rainrall and stored soil moisture on dry lands of western Rajasthan. Ann. Arid Zone. 18(1); 19-29.

f) Soil Moisture affects the efficiency of fertilizer use in two ways:

i) by improving the uptake of nutrients

ii)by increasing dry matter production.

Improved agronomic practices like the use of high yield variety, optimum sowing time and adequate crop stand, coupled with early and complete weed control are pre-requisites for getting the best out of the fertilizer use in term of kg grain/kg of fertilizer input.

g) Weed Control - Weed free plots of pearl millet, maize and sorghum gave mean yield of the order of 17.8, 46.6 and 14.6 q/ha as against 9.3, 17.6 and 9.2 q/ha. obtained from unweeded (check) plots.

h) Insects Pests and Plants Diseases - Field sanitation contributes to keeping the harmful insects at a low level of incidence. Other cultural practices include sowing, crop rotation, tillage, sowing trap crops, strip cropping. Even at present, appropriate cultural methods used. Best results are obtained by adopting an integrated pest control system.

3.1.4. Improvement in Grasses - Some of perennial grass species which had been scarce due to their over exploitation by way of uncontrolled grazing. These are *Lasiurus sindicus* (Sewan), *Cenchrus ciliaris* (Dhaman or Anjan), *Cenchrus setigerus* (Moda Dhaman), *Panicum antidotale* (Gramna) and *Dichanthium annulatum* (Karad). These grasses are fast growing, palatable, nutritious and possess high forage yield potential.

3.1.5. Afforestation and Social Forestry - Species are selected cautiously for desert afforestation. In arid areas planting of nursery raised stock has a definite advantage over direct seeding. So far massive afforestation, stock is to be prepared in the nursery well in advance of the planting season.

As the faulty land use is practised in the arid regions priority is to be given to such lands which are very arid. The priority is also fixed on government waste land and on community land. Generally lands available in arid areas for afforestation are of the following types:

i. Sand dunes

ii. Government waste land or depleted forests

iii. Community lands void of tree crops

iv. Farm bunds of individual farmers

v. Roadside strips

vi. Other refractory areas.

In order to translate this massive afforestation scheme in the arid zone of Rajasthan into action, an organisation was set up in July 1978 under the State Forest Department in the name of Directorate of Desert Afforestation and Pasture Development in Jodhpur. The major plantation schemes of this organisation are:

i. Silvi pastoral plantation

ii. Village fueld wood and fodder plantation

iii. Sand dune stabilisation

iv. Road side plantation

v. Farm forestry.

(i) It is a system combines the practice of growing trees with grasses and it provide fuel and fodder along with grazing ground for local cattle meet the need of small wood and timber.

(ii) The species taken up for plantation are ones which are suitable for fuel or fodder. The planting is done in dug out pits of 45 cm^3 at a spacing of 3 x 3 m. In interspace between pits, sowing of suitable species of grass is done.[24]

(iii) Fencing is required, locally available brushwood is collected from nearby areas and then buried

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24. Mathur, C.M. 1985. Plantation for fuel, fodder and small timber in Rajasthan. Trans. Isdt. & Veds. 10(2): 1-8.

vertically crown down-ward in lines 2 to 5 m apart. These lines are laid from the crest down to the heel on either side of dune in parallel strips, at first across the prevailing wind direction and then perpendicular to it having a criss-cross pattern.

Afforestation of such treated dune is done by nursery raised planting stock. Planting of seed-lings along the leeward side of the mulch lines, grass seeds are sown. The successful exotic spe-cies in duny habitats are Acacia tortilis, Prospis chilensis, Dichrostachys nutans and Acqcia nubica. Acacia tortilis is best species both as regards growth and survival on dunes. Grass like Cenchrus lasiurus sindicus are ideal.[25]

(iv) For road side plantation tall saplings of tree crop raised in polypots are preferred. Plantation work starts with onset of monsoon. Adequate provision of supplementary irrigation has been kept in road side plantation. At every 1 km. length, one tank is constructed for storing water

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25. Mathur, C.M. 1986. Sand dune stabilization and improve-ment of desert ecosystem in Rajasthan. In Current Practices in Geotechnical Eng. (Ed. Alam Singh), Vol.3, pp. 69-77.

and it is refilled time to time by water brought by tanker or tractor trollies. Species like *Azadirachta indica, Albizzia lebbeck, Acacia tortilis, Cassia siamea* are chosen for the internet row. Pongamia pinnata, Acacia tortilis, Tamarix articulata, etc. for the outermost or last row.

(v) Tree plants are planted along the farm boundary of individual farmers. Plants would provide wind breaks and meet nearly the farmer's entire fuel requirement. Forest Department supplied the plants to farmers and technical advise was provided. For farm forestry, Prospis cineraria, Acacia nilotica, Zizyphus mauritiana, Dalbergia sissoo leucaena leucocephala, Cordia, Tecomella undulata and Morus alba are preferred.

3.1.6. Social Forestry - It is to establish and maintain wood lots or tree groves in various sites, viz., road sides, farm lands, canal banks, railway lines, marginal lands, common meeting places, school compounds, etc. to meet the requirement of small timber fuel, fodder, shade, etc. It includes farm forestry in which creation of wind breaks around farms to conserve moisture and to protect the crop from wind is done. There is creation of farm wood lots in certain percentage of farmer's land for fuel, fodder and small timber. Raising of shelter belts on large government lands across the wind direction so as to save small holding of an individual, there is creation of small wood lots in village common lands, afforestation along canal banks, railway lines, road sides, catchment area, eroded lands, sand dunes, coastal areas, river margins and on areas unsuitable for agricultural purposes.[26]

3.2 Management of Water

Arid zones are characterised by low and erratic rainfall, extreme variations of diurnal and annual temperatures, high evaporation rate and high wind speed. The mean annual rainfall of the arid regions in India varies from 100 mm in the north-western sector i.e. Jaisalmer district of Rajasthan to 450 mm in eastern boundary of the arid zone in Rajasthan. It varies from less than 300 mm to 500 mm in the arid zone of Gujrat and from 200 to 450 mm in the Haryana-Punjab region. In view of scarce water resources and low rainfall, the production of crops, pastures or orchards in

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26. Muthana, K.D. 1978. Improved techniques for tree plantation in Arid Zone. Technical Bulletin, No.2, CAZRI, Jodhpur.

these zones should, therefore aim at making the most efficient use of the scarce input, water.

Water is vital natural resource. It is the life line for efficient crop production. So it is practised to utilise the rain water properly from hill sides, rocky areas, slopy waste lands as well as water sheds, generating maximum possible run off. Management of water includes:

(1) Water Harvesting Systems for Arid Zone.

(2) Management and Recycling of run off water in the Indian Arid Zone.

3.2.1. Water Harvesting System - practice of collecting water from an area treated to increase run off from rain fall. "Water harvesting" is the process of collecting natural precipitation from prepared water sheds for beneficial use. In Western Rajasthan, a chronic drought prone area the practice of harvesting water from roof tops. This water is collected in artificially made structures known as *tankas*.

Techniques of Water Harvesting

a. Water harvesting where water is stored in the soil profile itself.

b. Catchment water harvesting where the water is stored in a reservoir or pond for recycling when needed.

Scientists have tried several techniques to augment run off water both for conservation and for collection in farm ponds. The conservation techniques are as follows:

(i) Inter-plot water harvesting

(ii) Inter-row water harvesting

(iii) Pit and trench method of water harvesting for vegetables and fruit crops

(iv) Desert strip water harvesting

(v) Bench terrace water harvesting.

(i) Run off water is contributed to cropped plots by adjacent base plots either on one side or both sides. These adjacent plots are provided with certain slopes to augment the run off water towards cropped plot for increasing available moisture in the soil profile to saturate the root zone. But the disadvantage is with this system is that a large area has to be kept uncropped but this decreases the profitability of crop failure during unfavourable rainfall conditions.[27]

(ii) Inter-row Water Harvesting System: This harvesting system, planting is done in the furrows and each furrow

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27. Yadav, R.C., R.P.Singh, and Y.S. Ramakrishna 1979. A comparative study of run off potential of different water harvesting system under arid conditions. Trans. Isdt. & Veds. 4(1): 30-34.

is alternated by micro-catchments on either side. This system is more practical feasible and acceptable to farmers since no land is sacrificed for harvesting water. But if there is a rainfall with high intensity soon after sowing, the top loose soil of the micro-catchment caves in, as a result problem of poor germination occurs. This system is modified and named as Modified Inter-row Water Harvesting System in which each furrow is alternated by flat catchment on one side and ridge with side slope on other side.

(iii) Under this technique, trenches are dug with the scrapper or mannually upto 7o or 75 cm. depth. The sides of trenches are cut diagnally. Bentonite is applied @ 40 t/ha at the bottom of the trench, mixed in 2.5 cm of soil depth. Sides of the trenches are dusted with bentonite. Trenches are then refilled. Micro-catchments with 5 per cent slope on both sides of trenches (inverted V shape) are prepared. Finally the catchments are compacted with a roller. Catchment cropped area ratio may be kept from 1:1 to 1.5:1. The technique is suitable for growing vegetable crops like ladies finger and cucurbits on drylands.[28]

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28. Singh, H.P., R.P. Singh and Kailash Singh, 1979. Effect of bentonite sub-surface moisture barrier and run off construction on soil moisture storage and yields of round grown in sandy soils. Int. J. Agric. Sci. 49(11): 382-388.

(iv) Desert strip water Harvesting technique uses water harvesting from a collector area to help in supplying the moisture requirements of a cultivated crops on a smaller farmed area. This system suitable for lands having regular and continous slopes.

(v) This system uses most of the principles of run off farming to conserve and utilize run off for grain production. The conservation bench terrace system uses level contour benches with terrace ridge to control erosion and retain spread and infiltrate storm runoff from cultivated contributing areas that are not treated to increase run off. This system is suitable for sloping lands.

- The selection of water harvesting system depends upon the rainfall characteristics and soil type of the region, available land and its topography, crops to be grown and the benefits likely to accrue. In area of high scarcity of water, small ponds may be constructed for storing the water for drinking purposes of livestock and domestic use only.

3.2.2. Management and Recycling of Run off water in the Indian arid zone:

(i) Run Off Management: This includes maximum possible inducement of run off from a catchment, efficient storage in reservoir, efficient conveyance to the field and right amount and optimum use of water through efficient method of application at the right time for successful farming in arid and semi-arid areas.

(a) Inducement of Run Off - The surface treatment of soil with bitumen and asphalt was found to be effective for inducement of runoff. The runoff water so collected was good and could be used for irrigation and animal consumption.[29] Chemical treatments and ground cover though found very efficient and successful in collecting run off. They are not yet economically attractive enough to generate wide spread adoption.

b) Efficient Storage in Reservoir - Harvested water saved by adopting techniques to control seepage, evaporation losses and sedimentation Asphalt coating, soil cement and mixture of cow dung, straw and soil. Tank silt mixed with sodium carbonate and janta emulsion were highly effective in reducing seepage. Application of sodium bentonite at the rate of 0.30 to 0.91 lb/m^2 is very effective in reducing seepage in soils containing

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29. Tiwari, K.N. 1991. Rainwater harvesting technology: A Review, Ind. J. Soil. Conservation. 19(3): 37-44.

high percentage of sand. For reducing evaporation losses, a chemical compound Hexadecanol which spreads in monomolecular layer once water surface has been found to be most promising compound. But the difficulty in its use lies in maintaining a layer in tact on water surface because of higher wind speeds prevailing in arid zones. For sedimentation control, converting slopes into vertical drops by terracing, stabilizing soil by turfing and by plant growth and constructing check dams.

ii) Recycling of run off water - During prolonged dry spell, the stored run off water have been applied to the crop by efficient method of irrigation which gives maximum return per unit of water. Traditional methods of irrigation, i.e. flood, check basin border irrigation, etc. are of little consequence, as losses are high and efficiency of utilization is low.[30]

a) Furrow Irrigation - The furrow irrigation system used to irrigate all cultivated crops planted in rows, including orchards and vegetables with

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30. Jain B.L. and R.P. Singh, 1980. Run off is influenced by rainfall characteristics, slope and surface treatment of micro catchment. Ann. Arid Zone (19 (1&2), 119-125.

distinct advantages over other methods of flood irrigation water in the furrows contact only one half to one fifth of the land surface, thereby reduces evaporation losses. In the soils, where lateral movement of water is fast, alternate or skip furrow irrigation method can be adopted.

b) Sprinkler Irrigation - This is most suited to sandy soils, which have high infiltration rates. In this with the same quantity of water, more area can be irrigated compared to flood system. Due to controlled supply of water, deep percolation and run off losses are completely checked. The method is adaptable to most topographic conditions without extensive land preparation. It is ideally suited to steep slopes or irregular topography and the cost of levelling is reduced.

c) Drip Irrigation - Latest method of irrigation. The system applies water in the form of small drops to keep the soil moisture within the desired range for plant growth. It is very useful in water scarce area, where soil is too porous for flood irrigation and where land levelling is very costly. This system is most effective for permanent trees, orchards and sow crops.

3.3 Management of Agriculture and Cropping System

The potential of Indian arid and semi-arid regions are developed by using concepts and methods, which are best suited to dry areas. Agricultural engineering plays an important role in maximisation of production in arid zone. The improved and appropriate agricultural engineering practices along with others for improving the present situation of arid zone are as follow :

(i) Tillage and seeding practices conducive to good crop stand.

(ii) Soil and water conservation practices - contour tillage.

(iii) Tillage practices and Machinery to control soil blowing.

(iv) Water Harvesting and run off recycling techniques.

(v) Surface moisture Barrier

(vi) Desert Strip (contour catchment) Farming

(vii) Trickle irrigation

(viii) Solar Energy Utilization.

(i) Ideal tillage practice results in uniform initial stand, maximum weed control and should also result in the coverage of large areas during the restricted sowing period. Deep ploughing treatment result highest grain yield and lowest incidence of weed infestation.

Tillage implements (V-shaped sweeps or straight or curved blades blade narrow etc.) used which cut beneath the soil surface without turning the soil. Seed is placed at the proper depth in relation to its size and soil moisture and is uniformly distributed. Noble seed drill is superior. Highest grain yields of pearl millet (10 q/ha) was obtained by seeding with the newly developed CAZRI bullock drawn seed cum fertilizer drill followed by Noble seed drill.[31]

(ii) Contour tillage helps in reduction of soil loss and encourages more conservation of moisture, increases crop yields.

(a) Contour farming - helps in soil and moisture conservation.

(b) Contour bunding - beneficial practice in precarious rainfall tracts.

(c) Khadins - practice of soil and water conservation, prominent where the soil moisture is main problem.

(d) Emergency tillage - for example, ploughing against the prevailing wind direction by duck foot shovels that roughen the surface and reduces the impact and threshold velocity of winds, reducing wind erosion.

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31. Singh, R.P. Improved Dry Land Agriculture for Western Rajasthan, CAZRI Tech. Bull. No.1, 28 p.

(iii) Best implement in a properly angled one way disk plough which leaves the material in a partially standing position. The surface roughness is created by a lister, which is a tool particularly suitable where residue covers are poor.

(iv) This technique provide additional quantities of moisture, inter-plot and inter-sow is suitable for conservation of water. Run off farming offers potentiality for increasing and stabilising yields, and lower the risk of crop failure.

(v) To cut down losses owing to deep percolation, a technique of partial moisture barrier (bentonite clay) incorporation has been developed at CAZRI.[32] The placement of bentonite barrier 75 cm deep in pits gave an yield of 160 q/ha of tinda against 110 q/ha obtained from the land where no such barrier was applied.

(vi) Desert strip farming is a modification of micro-catchment farming. It employs a series of terraces that shed water onto a neighbouring strip of productive soil. They are often tried up a hill slope, but on level terrain an artificial slope for the catchment can be made by mounding soil between the strips.

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32. Singh, Mp.P. 1978. Improving the moisture storage in sandy desert soils by sub-surface moisture barrier. Proc. Int. Symp. Arid Zone Research & Devt. (Ed. H.S. Mann), pp. 245-252.

(vii) Drip or trickle irrigation was a system of plastic pipes placed among the plants on or under the soil. Water carried in the pipes drips onto the soil through outlets arranged near each plant, because only a small amount of soil is watered, evaporation losses are minimised, and rate and time of water application are adjusted for no run off and minimal deep percolation losses.

(viii) Solar dryers for drying agricultural produce, and seed treatment, solar cooker, solar oven and solar pumps, etc. are some instruments for utilisation of solar energy source.[33]

3.3.1. Inter-cropping Systems

Inter-cropping systems are defined as the growing of two (or more) crops simultaneously on the same piece of land and each crop occupying separate rows. Inter-cropping has distinct advantages over mono-cropping. Greater stability of yield over different seasons is most attractive feature of the inter-cropping system.

(i) Inter-cropping with perennial forage grasses - Annual grain legumes were considered as inter-crops with

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33. Garg, H.P. 1977. The utilization of solar energy in the arid zone and semi-arid zones of India. In Desertification and Its Control, (Ed. P.L. Jaiswal), pp. 301-309.

forage grasses which are considered to be useful in building up soil fertility of innesently poor arid zone soils. Inter-cropping of grain legumes viz., mungbean, mothbean, clusterbean with Cenchrus ciliaris (CC) and Lasiurus sindicus (LS) gave much encouraging results giving 2.2 to 2.8 q/ha of grains and 21 to 35 per cent increased forage yield. In view of experimental evidences, it can be concluded that inter- cropping of annual grain legumes with grasses is feasible and a profitable preposition.

(ii) Inter-cropping system involving only Annual Crops:

(a) Inter-cropping of Annual Grain legumes with sunflower - Mungbean, mothbean, clusterbean, cowpea and groundnut were grown as intercrops in sunflower planted in regular (60 cm) and paired rows (40/80 cm) over two years. Result indicated that inter-cropping of mungbean, cowpea, mothbean and groundnut did not affect the seed yield of sunflower adversely while clusterbean although produced highest grain yield among the intercrops. Total productivity of intercropping system was 75 per cent higher than the paure cropping of sun flower.[34]

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34. Singh, K.C. and Singh, R.P. 1977. Inter-cropping of annual grain legumes with sunflower. Indian J. Agr. Sci. 47(11); 563-567.

(b) Inter-cropping of pearl millet with mungbean - In a trial on system of planting mungbean with and without an inter-crop of pearl millet carried out for two consecutive year 1975 and 1976 revealed that the yield of the base crop (mungbean) decreased markedly as a result of planting one row of pearl millet under any of the planting systems. However, the yield of pearl millet was highest in paired rows planting of mungbean + one row of pearl millet. Further yield of the base crop was reduced by 3.6 q/ha and as against this loss, planting of one row of pearl millet in inter-space resulted in an additional grain yield of about 22 q/ha of pearl millet.[35]

(c) Inter-cropping in clusterbean - Inter-cropping system involving planting of one row of pearl millet fertilised @ 15 and 30 kg N/ha and unfertilized in the inter-spaces of clusterbean planted in paired rows resulted in significantly higher productivity over the pure stand of clusterbean in normal rainfall year and inter-cropping system of

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35. Singh, R.P., K.C. Singh and Y.S. Ramakrishna, 1978. Effect of system of planting pearl millet on the yield, total productivity, moisture use and monetary returns. Indian J. Agri. Sci. 48(3): 138-142.

planting one row of pearl millet fertilized @ 15 kg N/ha in paired rows of clusterbean gave highest monetary returns.

Table No. - 4

Livestock Population in Different Agro-climatic Zones in Arid Zone of Rajasthan

Agro-Climatic Zones	Area (000' hectares)			Total Live-stock ACU (million)	Land Available in ha/ACU			% Shortage of forage during normal years
	Total	Under cul-tivation	Grazing		Total	Cultivable	Grazing	
Zone of Avg annual Rain-fall Below 300 mm	11,498	3,610 (31.4)	5,785 (50.4)	2.043	5.63	1.76	2.83	42.0
Zone of Avg annual Rain-fall 300 mm and above	9,361	5,741 (61.3)	2,777 (29.7)	4.69	1.99	1.22	0.59	35.0
Total	20,859	9,351 (44.8)	8,562 (41.1)	6.733	3.09	1.38	1.27	35.1

Figures in parenthesis indicate % of area under cultivation and grazing, ACU = Adult Cattle Units. Average dry Fodder reuirements/ACU is 2.5 ton/year.

3.4 Management of Livestock

3.4.1. Management of Livestock - In Rajasthan, animal husbandry is not a mere adjunct to agriculture, but it is a major economic activity contributing over 12 per cent of the total income of the State; two-thirds of the earning members of households in arid western part of the State followed animal husbandry as their main occupation.

Table No. - 5

Livestock and forage needs and availability (at 66% level ofoptimum production) in the arid zone of Rajastan

Year	Adult cattle Cattle (million)	Forage (Milion Tonnes) Needs	Availab	Shortage	Forage shortage (percentage)
1975	6.733	16.830	10.169	6.664	39.6
1980	7.406	18.517	11.693	6.824	36.8
1985	8.146	20.366	13.316	7.050	34.6
1990	8.961	22.400	15.466	6.934	30.9
1995	9.858	24.645	17.786	6.860	27.8
2000	10.834	27.085	20.459	6.626	23.8

Table No. - 6

Condition Classes of range lands and their carrying capacity

Condition Class of Range Lands	Forage Production (kg/ha) during normal years	Carrying capacity of adult cattle units (300 kg/body weight per 100 ha/year)
Excellent	1500 and abaove	25 - 30
Good	1000 and above	20
Fair	750	17
Poor	500	13
Very Good	200 or less	0 - 6

Source: Bhimaya and Ahuja (1969).

(i) Sustained Nutrient Availability - This basic ingredient is in short supply, the desert livestock management system is further complicated by high ambient temperature, low humidity, meagre water availability and salinity hazard. A combination of all these factors has made this refractory region particularly suitable for sheep and goat rearing. It is necessary to have both pasture grasses and top-feed yielding trees and shrubs. Pasture having a reasonably good perennial grass cover is available, the year long nutrient supply from this pasture will show considerable fluctuations which will be reflected in the health of the grazing animals, e.g. protein content of Cenchrus ciliaris may be 16 per cent during the monsoon, falling to 8.5 per cent by October and eventually to the very low figure of 4.5 per cent by December. Concurrently, the crude fibre content which is the most undigestible part of the feed, increases from about 5 per cent during monsoon to as much as 40 per cent in the mature feed.

(ii) Pasture Management - (a) Over-grazing of pastures has to be regulated, (b) as far as possible, perennial grass pastures should be cultivated, (c) pastures should have legumes, grasses as well as fodder trees, (d) sown pastures of improved grass varieties should be propagated.

Deferred and rotational grazing systems allow for regeneration of pasture grasses. Many studies have shown that both desert adapted sheep and goats have lower physiological needs of water than what they actually consume.[36] Salinity hazard is a common feature of desert surface water. Study indicate that any water that contains upto 2000 ppm total soluble salts is tolerated by both sheep and goats reasonably well, although the long term effects of this level of salinity on productivity potentials have not yet been assessed.[37]

Poverty, orthodox concepts and unprofitable returns prevent the desert farmer to inject newer knowledge of animal husbandry into his profession. The government has to take the initiative in storing surplus fodder in a good year in fodder banks "strategically located for use during lean periods. Boring of wells along the traditional routes of migration is another essential requirement. Our livestock management system, particularly with respect to sheep and goats, should be based on a policy of "select and cull" from among the adapted, indigenous breeds rather than one based on cross-breeding with high producing exotics.

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36. Ghosh, P.K. and M.S. Khan, . The Goat in the Desert Environment CAZRI Monograph, No.12, CAZRI Jodhpur, 26 p.

37. Mittal, J.P. and P.K. Ghosh, 1983. Long term saline drinking water and female reproductive performance in Magra and Marwari sheep of the Indian desert. J. Agric. Sci. 101: 751-754.

Forage Production - The production of forage in arid zone of Rajasthan is presented in Table 7. In normal years, forage needs are just met with zone with mean annual rainfall below 300 mm, while there is deficit in zone with annual rainfall above 300 mm to the extent of 16.4 per cent giving an over all deficit of 8.4 per cent for the arid zone of Rajasthan. With the progressive increase in human population, the demand of human population for livestock products like milk, milk products, meat, wool, transport, drought, etc. will progressively increase. By adoption of improved technology in a phased manner, it is assumed that there would be an yearly increase of about 2 per cent in livestock population and 3 per cent in forage production,[38] and it is estimated that forage will continue to remain in deficit supplies in zone with annual rainfall above 30 mm.

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38. Ahuja, L.D. 1975. Range Management and Forage Production in India. Write up for National Commission on Agriculture, Government of India & CAZRI Monograph, Jodhpur.

Table No.- 7

Production potential of forage from different agroclimatic zones in the arid zone of Rajasthan during normal years of rainfall

Land utilizaton Pattern	Zone A Rate (t/ha)	Area (000'ha)	Production (t/ha)	Zone B Rate (t/ha)	Area (000't)	Production (000't)	Total Production (000't)
Forest	4.0	43.0	12.9	0.4	125.7	50.3	63.2
Pastures	0.3	313.8	94.1	0.4	527.4	211.0	305.1
Tree groves	0.3	1.1	0.3	0.4	0.1	0.0	0.3
Cultivable wate	0.3	4293.7	1288.1	0.4	166.9	66.8	1354.9
Fallow	0.3	620.0	186.0	0.4	977.1	390.8	576.8
Current fallow	0.3	513.5	154.1	0.4	979.7	391.8	546.0
Cultivable area	1.0	3609.6	3609.6	1.5	5741.4	8612.1	12221.7
Fodder crops	3.0	89.5	268.5	4.0	17.9	71.6	340.1
Total			5613.6			9794.5	15408.1
Forage need for livestock			5108.0			11725.0	16833.0
Shortage			+505.6			-1930.5	1424.9
Percentage			9.9			-16.4	-8.4
Grazing land			5785.1			2776.9	8662.0
Cultivable area			3609.6			5741.1	9350.7
			9394.7			8518.0	17912.7

Zone A - Mean annual rainfall below 300 mm.
Zone B - Mean annual rainfall above 300 mm.

3.5 Technology Transfer in India

Agriculture extension agents and the key players for technology transfer fulfiling numerous roles work as an agent in helping farmers to adopt a new technology. Extension agents are usually associated with state agricultural university or state department of agriculture or reputed research organisations. They reflect current research findings. They provide high quality information and services. Extension organisations deal with transfer of technology for the benefit of farming community. Before performing their tasks they master the special technology through training. Training is effective for their performance. Extension agents must know the clients problems and their solution, knowledge of farm economics, input supply and marketing, communication skill, etc. Training of extension aspect is very important part for technology transfer. There are different types of training includes overseas training and farmers training.

(a) Farmers Training - In the process of technology transfer the training of farmers, farm leaders, rural youth and women play an important part. Farmer's training is the process of non-formal education which educates the farmers in a group one some specific topic at a particular place. A group of farmers, farm leaders, women or farmers' sons are brought to à training centre and are provided training for a certain period on some specific subject matter. The farmers can also be trained on some technology right at their home or farm through regular visits by extension workers. The subject matter specialist at the block level under the T&V system train the contact farmers by delivering carefully prepared impact points through their fortnightly visits. Besides farmers training centres, there are regular farm ers training programmes in all agricultural universities. The training programme covers crop-raising, annual feeding and management and plant protection. Some of the universities run schools for farmers' sons. Punjab and Haryana Agricultural Universities are having this facilities. This can very well be utilised for farmers training also. National level farmers voluntary organisations are being encouraged to take up training programme for the benefit of young farmers by organising short duration training courses, seminars and exchange visits. Financial assistance is being provided by the directorate of extension to enable these organisations to undertake programmes relating to agricultural production. The People's Action for Development in India (PADI) receive aid from FAO and other donor countries to provide assistance to voluntary organisations and training institutions for taking up programmes for rural youth development and young farmers training. Some of the projects which were financed under this programme are: (a) Kitchen garden competition among rural youth clubs around selected extension training centres, (b) Development of village youth clubs in district Agra, (c) Poultry development programme through youth clubs in selected villages, (d) establishment of young farmers training centres.

Farmer Training Centres (FTCs) - At present there are 131 FTCs functioning in India.

(b) Role of Indian Council for Agriculture Research (ICAR) in Training: ICAR is an apex body involved in training at various levels. It has 42 Central and National Research Institutes, 4 National Bureaux, 9 Project Directorates, 22 National Research Centres, 70 All-India Coordinated Projects, 27 State Agricultural Research Projects, 109 Krishi Vigyan Kendras and eight Training Centres. Apart from this administrative sanction of 74 new KVKs has also been issued.[39]

(c) Krishi Vigyan Kendras (KVK) - ICAR has started a scheme to establish KVKs in the country. The Kendras will impart training only to those extension workers who are already employed or those who wish to be self-employed. The syllabus and programmes of each Kendra will be tailored according to the felt needs, natural resources and the potential for agricultural growth in that particular area. Generally the training programmes will cover the topics of cultivation of local

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39. Employment News, April 29-May 5, 1995, pp.1-2.

crops, application of package of practices, farm planning and plant protection, care and feeding of animals, poultry keeping, tube well operation, irrigation and water control, nutrition, cooking and hygiene food processing and cooking, marketing of agricultural products, catching and marketing of fish, etc.

Trainers Training Centres - ICAR has established seven Trainers Training Centres in different parts of the country to provide specialised training to the teachers of Krishi Vigyan Kendras. The objective of this is to impart training to the teachers of KVKs both in agricultural technology as well as pedology to train the teachers who are likely to be engaged in teaching or work experience in agriculture and home economics in high schools, to train trainers of gram sevak/service extension training centres of the region, to organise vocational training programmes in agriculture and home economics. Initially seven Trainers Training Centres were created.

KVKs, TTCs are both innovative and institutions for practical training of the farmers and in service personnel and hence more investment will be required.

(c) Extension Training Infrastructure - At present 34 ICAR institutes, 27 State Agricultural Universities, 207 training and Visit Monthly Workshop Centre, 84 village extension workers training centre, 109 Krishi Vigyan Kendras (administrative sanction of 74 new KVKs during Eighth Plan period has also been issued), 8 Trainers Training Centres, 4 Extension Education Institutes (are imparting training to the farm scientists, subject matter specialist, village level workers and the farmers), 13 Advanced Centres of Training (ACTs), reconducting training in ten areas of specialisation on dry land agriculture, oil seeds, water management, wheat, rice, plantation crops, horticulture and plant protection. Apart from this government of India, has established National Centre for Management of Agriculture Extension (MANAGE) at Hyderabad. MANAGE will act as training leader at the national level in the field of extension management. MANAGE has established firm linkages with extension education institutes (EEIs), State Agriculture Universities (SAUs) and State Department of Agriculture (SDAs). The extension training of MANAGE will focus on extension project planning and administration extension personal management, training of extension personnel, research extension projects and

monitoring and evaluation of Extension Projects.[40]

State Governments have the basic infrastructure and also the trainers at gram sevak training centres to take care of the present training needs of . The institutions could be strengthened and equipped adequately to fulfil the training requirements. The trainers from these centres should also be updated in their specified areas. In order to meet the requirement of management skill, it may be worthwhile to develop a state level training centre. Besides this proper linkage among MANAGE, the regional institutes, EEIs, Centre of Advanced Training and State training institute should be necessary to achieve the desired objective. This linkage could be in the form of training preparation, developing of training infrastructure and proper relationship by utilising trainers services from one institute to other so that training is conducted with the optimum utilisation of resources.

But there are problems of training also. The main problem is making training effective that is (i) what is taught to the trainees is often not relevant to their work or situation, (ii) the trainers do not know the techniques of transferring their knowledge to

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40. Employment News, Apr. 22-28, 1995, pp.1-2.

trainees, (iii) lack of clear concept about training and wrong attitudes of trainers and trainees, (iv) lack of proper motivation and incentives, (v) Reasonable methods of assessing effectiveness of training are absent, (vi) Problems of recruiting the right kind of trainers and trainees, (vii) disparities of socio-psycho economic status of trainees in a group, (viii) information over leading, (ix) lack of communication and feed back in the post-training phase.

Training of both extension personnel and farmers is a useful tool for technology transfer in agriculture. It is costly investment and must be planned, budgeted and evaluated with ease. In agriculture extension, farmers are the key elements that must be changed and in doing so the role of technology transfer can never be over emphasised. Personnel and various levels in an agricultural extension organisation need to be equipped with adequate and upto date "know hows" and "do hows" of dealing with problems of people. Appropriate training programmes for these personnel will definitely contribute significantly towards their development in knowledge skills and attitudes. But mere providing of training will not help much in bringing desired change in people unless proper arrangements and environments are created for the application of knowledge and skills, gained by the participants through the training programmes.[41]

Transfer of technology being a complex and continuous process there is no alternative but to develop human resources to achieve desired goals. The effective manager of extension organisation are those who can best develop all human resources (including farmers) involved in planning, implementation and evaluation extension programmes for the purpose of achieving organisational objectives. In this respect, training must be considered as continuing function and process of training and retraining of the available human resources must be an integral part of any organisational programme.

Science and Technology hold out the promise of fulfilling the basic needs and improving the quality of life of people. Given all the ingredients essential for progress, the pace and quality of progress will depend on the scientific management of resources and blending of resources and technology in a manner that will generate symbiosis and energy.

Technology transfer cannot remain a one way process if we want to make proper use of improved indigenous technolo-

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41. Sanjaya Lall 1993, Promoting Technology Dev't. The role of Technology transfer and indigenous effort Third World Quarterly, Vol. 14, pp. 97-104.

gy, we must pay increasing attention to R&D to keep abreast of other countries, otherwise we shall be left with an outdated technology and not be able to compete the world markets.

So, in the conclusion we can say that participatory technology development should be adopted, which is not development in itself, in the way that community development or small scale industrial development. It is an approach that contributes to the development by ensuring that cases where a better technology is needed to help, solve a problem, the technology chosen will be the most appropriate one. And the emphasis on the participation in the process of identifying, improving and adopting a technology to the local context will also increase the technological competence of the people involved.

CHAPTER - IV

ISRAEL'S EFFORTS FOR DESERT MANAGEMENT

4.1. **Israel desert, its extent, and climate**

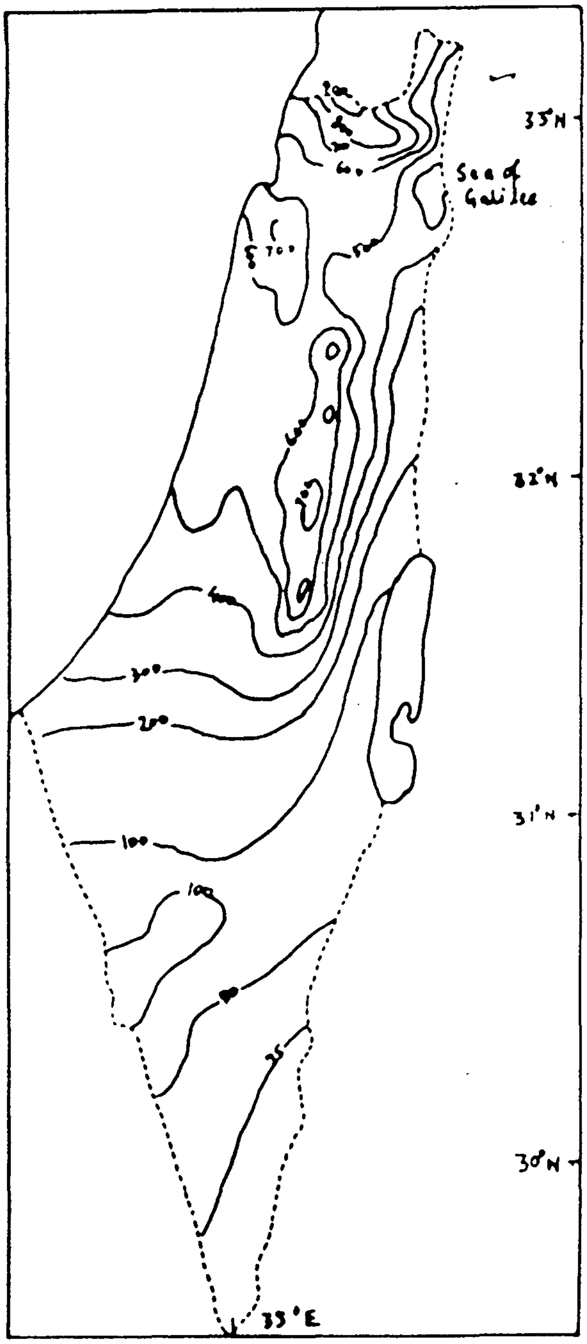
Negev Region is the desert region of Israel which is situated on the southern part of Israel. Negev is rather small but it is in fact, only a muscule part of the great desert belt of North Africa and South West Asia and being on its fringe, it is not, for the most part, an extremely arid desert. Negev is very compact and distinct which make it an ideal place for study the experiences of the past and potentialities of the present with regard to the development and utilization of land and water resources in a desert environment.

Negev desert is shaped like an isosceles triangle, with its northern base running from Mediterranean coast south of Gaza to the southern basin to the Dead Sea. From these extremities the sides of the triangle stretch well over 160 kilometers south to the apex at Eilat on the tip of the Gulf of Aqaba. The Negev thus appears to be thrust, like a giant dagger or wedge, into the great Eastern Desert, separating Sinai from Arabia. The boundaries of the Negev coincide roughly with the present day borders of Israel with Egypt (on the West) and the kingdom of Jordan (on the east). The northern boundary of the Negev is rather indistinct. Toward the north west the loess-covered Negev plains change gradually into grassy Shefela plain and the thinly wooded judean foothills. Toward the north east the Negev blends into the jordean Desert, overlooking the Dead sea, with out any clear line of demarcation. The eastern boundary of the Negev is the most distinct. It is the narrow, fault-lined Arava Rift valley, a spectacular gash in the earths crust, a sunken valley sharply marked on both sides by high cliffs. The Natural Western boundary of the Negev is the broad creek bed of Wadi El Arish, which runs some kilometers beyond the present day frontier between Egypt and Israel. It marks the transition between the rugged highlands of the Negev and generally flat gravel plains of Northern Sinai.

The climate of the Negev is rather typically continental and desertic. Mean annual rainfall decreases from 200-300 mm in the north-west to about 25 mm in the extreme south, and is confined to the winter months, November to April. The distribution of rainfall with in the rainy season is highly irregular, and the total seasonal rainfall fluctuates widely from year to year. A single freak rainstorm, a chance cloudburst, can spell the difference between a wet season and a dry one. The winters are relatively cool in the highlands and warm in the Arava, The summers are hot and dry every where, and exceedingly so in the Arava.

Map No. v

RAINFALL MAP OF ISRAEL



Rainfall map of Israel, with Isohytes (lines of equal rainfall) marked in mms of mean annual rainfall. Rainfall is concentrated in the mountains of northern Galilee and along the central negev mountain ridge of Samaria and Judea. The Israel's eastern slopes of these mountains, being in their "rain shadow" are relatively arid.

insolation is high, this coupled with dry winds that sweep over the land cause high rates of potential evaporation.[1] Most of the Negev-over 90 percent of the land area-consists of marine rudimentary rocks, primarily limestones and Chalks of varying degrees of hardness, ranging in the age tram. Triassic through Jurassic and Cretaceous to tertiary and Quaternary. There is some evidence of minor volcanic activity in the geological history of the Negev, including magnetic plugs and dikes and a few extrusive features. Thus the landscape is of rocky hills and mountains gravel paned plateaus, coarse sediments, and sands. Outside the north western sub-region these are only a few extrusive tracts of potentially arable soil. The typical soil of Negev is loess - a buff - closed, fine gained wind-borne deposit of desert dust. In the north western Negev where it is most extensive and in some valleys in the central Negev, the mantle of erodable can attain a thickness of many meters but in most places it is shallow. Though an unstable soil, highly crediblė by both wind and water, loess has favorable water-retaining characteristics that make it highly productive in places where water is available.[2]

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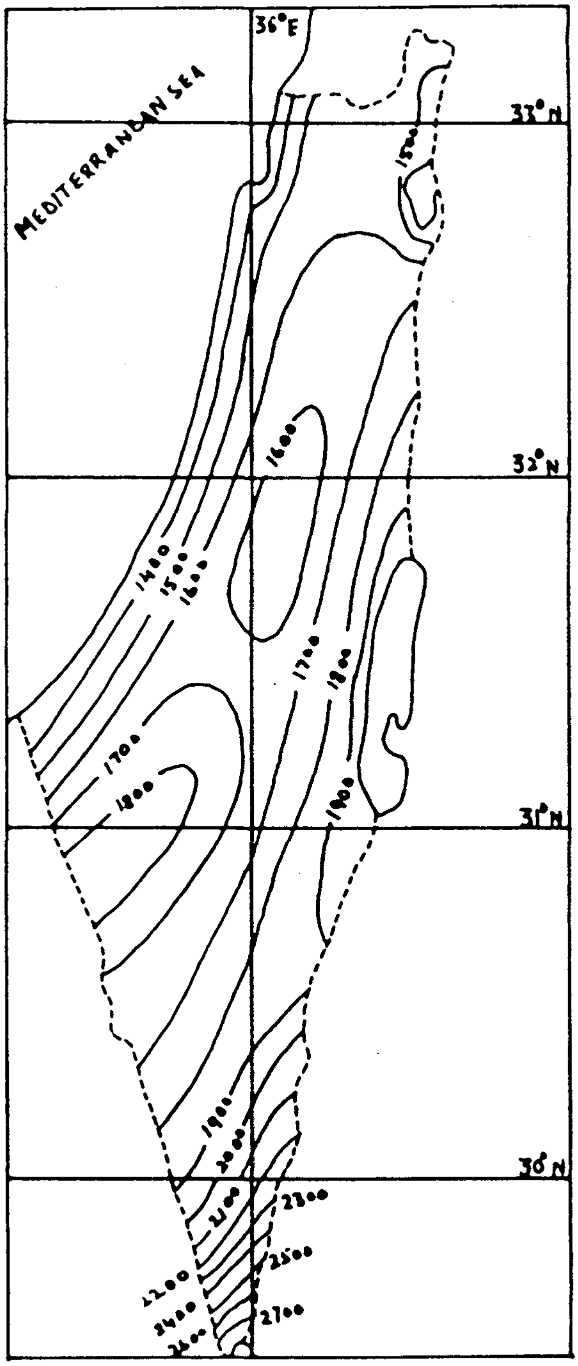
1. Ashbel, D. 1967, climate of the Negev. Jerusalem; Hebrew University.

2. Behtor, Y.K. 1979. Geology of the Negev. In the land of the Negev. Israel Ministry of Defence. Tel-Aviv

EVAPORATIVITY MAP OF ISRAEL



Evaporativity map of Israel. Showing lines of equal means annual evaporation (mm). as measured with a pan evaporimeter. The areas with the least rainfall suffers the greatest evaporative demand, and thus are even more arid than the rainfall alone would suggest.

With in the large triangle of the Negev, which occupies some 12,500 square kilometers (over half of the state of Israel), differences in topography, elevation, aspect, geology, hydrology climate and vegetation enable us to recognize four fairly distinct sub regions a) the north western plains b) the northern highlands. c) the Southern highlands d) the Arava valley.

a) The North-Western plains -

The northern plains subregion of the Negev constitutes Israel's main agricultural land reserve, its most extensive area of arable soil. Rainfed agriculture (dryland farming) is submarginal, too risky because of the frequency of drought. Irrigated farming is very successful here, but it depends almost entirely on the increasingly expensive importation of water from the north, since local ground water resources are their natural replenishment are exceedingly meager. The greater part of the Negev is mountainous, with several prominent ranges. The nighest of these is the Rama on, which attains an attitude of 1,000 meters and separates the Negev highlands into northern and southern subregions.

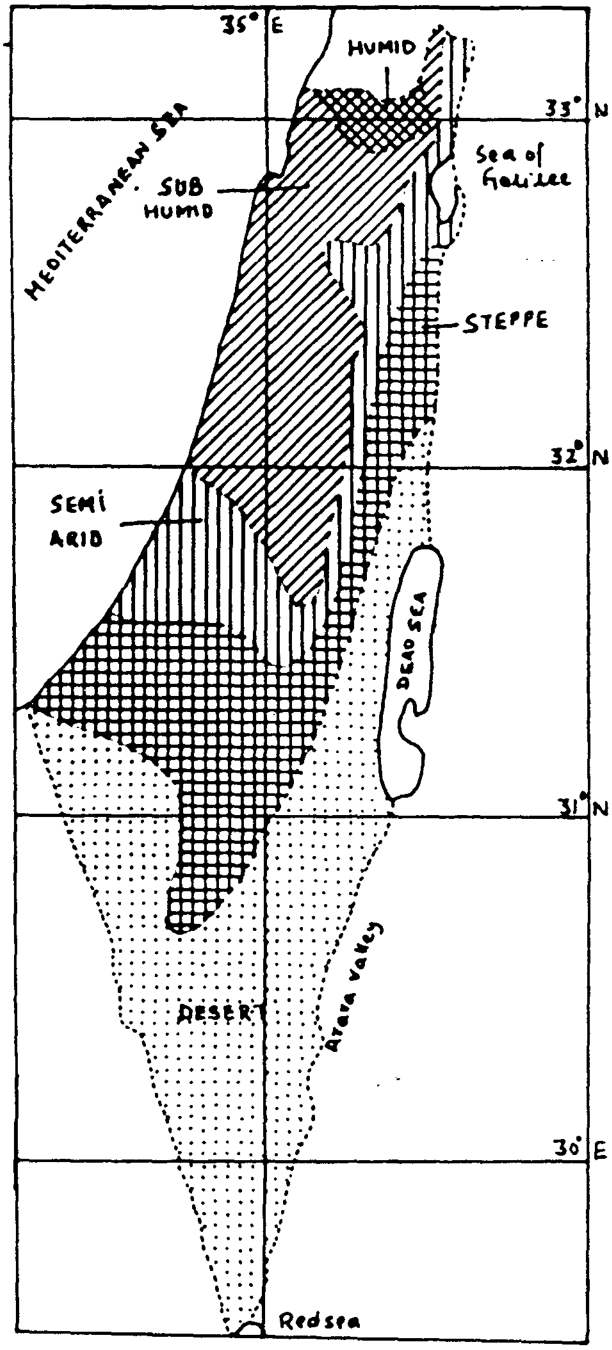
b) The Northern highlands - consist of parallel anticlinal ridges and synclinal valleys running from north-east to south west. These ridges are characterised by fairly gentle north-west facing slopes. A unique and spectacular feature of the Negev highlands in the occurrence of several large craters in the anticlinal ranges.

Because of the higher elevation, the northern highlands intercept rain bearing clouds and are wetter than the adjacent sub-regions at the same latitude. The mean annual rainfall is on the order of 100 to 200 millimeters. This subregion is also cooler than other parts of the Negev, with occasional frost in winter.

c) The Southern highlands - lie South of Ramon, the Negev's highest mountain range. Crossing that range south ward from its north-west facing side to its lee side, there is an abrupt change in hydrological and ecological conditions. Annual rainfall drops from more than 120 mm at the range's crest to less than 75 mm, then continues to diminish, and to little over 25 mm at the southern tip of the Negev triangle. Completely desertic condition prevail in this subregion, the landscape consisting almost entirely of rugged rocky hill and of hammadas. The vegetation is very sparse, consisting of dwarf desert shrubs. Numerous Acadia trees, however, grow in the local depressions and water courses.

d) Arava is a narrow, cliff lined valley running the length of the Negev triangle on its east side. It is the segment of the great African-Syrian Rift extending between Dead sea and the Gulf of Aqaba.

ECOLOGICAL REGIONS OF ISRAEL



Ecological regions of Israel, which gradually change from relatively humid conditions in the north to increasingly arid conditions in the south.

4.2. Israel's technology efforts for desert management

Desert is no more a wasteland. Israel's efforts to reclaim the desert have proved it in many ways. The country is a small and resource poor country where more than half the land area is desert. Therefore, to develop and colonize the desert was nowhere mere urgent and imperative than in Israel. Application of innovative and new technology made possible the reclamation, what had so long been considered wastelands Negev desert of Israel is one such success story. They developed the methods of land and water husbandry they also collected the run-off from slopes and built terrace walls across the creek beds in order to conserve water and soil and to raise crops even in the desert. Despite all this modern techniques of run off inducement and utilization in desert are still in their infancy. But the fast economic development also has some costs to pay modern roadways diminish the expanse and violate the primeval grandeur of the desert landscape, as do excavations, pipelines and various protruding structures. One writer on this subject reacts this development in this way "Let us respect and love the desert and seek to line with it, not rape or despoil it.

Israel certainly outclass India in technological development. Modern scientific measures in soil and water management are widely used in Israel but we are still in the infancy.

The process associated with desertification in Israel have been going on for many millennia and there has been no ecologically climatic change since fnany centuries. The Northern Negev border area has an extremely sharp rainfall gradient ranging from 400 mm 50 km north of Beer-sheva to 100 mm only 20 km South of the town, a gradient of over 4 mm per km. Any slight change could easily cause a north-ward of south ward shift of this isohyetal gradient which in turn would cause the northern border of aridity the population of these fringe areas. Climatic changes undoubtedly had a strong impact on the prosperity of the region.

Over grazing has been one of the destructive influences leading to desertification. The Negev has been intensively grazed for thousands of year and reduces the many palatable and nutritious plant species have been completely eradicated. Firewood gathering was and still an important factor in depressing the natural stands of trees and shrubs. This is especially true in those areas where human population is largest and where settlement has been continuous over many centuries.[3]

The Israel have gave efforts by putting high lance of input into the cropping systems and improved agricultural

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3. Schechter. J. The Negev the Biblical wiederness made productive <u>Desertification control Bulletin</u> - pp.8-14.

techniques, which helps in maintenance settled agriculture. The communal nature of agricultural organisation helped settlers to overcome the initial difficulties and increase the efficiency of resource utilization. Constant research activities have brought the farmers new high yielding and disease-resistant cultivars. Suitable methods of cultivation and crop rotation have been introduced with special attention to erosion control practices.[4] By such means Negev has become one of the most productive cereal producing area of Israel. This combination of technological means with social and economic incentives was the basis for the excellent result achieved over the last 30 years. The transportation of water from humid areas to dry areas through pipe lines use of drip or --- irrigation and installation of a modern irrigation system result in greater yield in Agricultural field.[5] Israel's has achieved success of Israel was the government policies which were planned in a broad set of policies, and implemented with coordination at all levels is National and Local.

The combination of grain farming, pasture and feed supplements allows for the flexible use of diverse sources

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4. Hillel, D. 1982. Advances in Irrigation, New York : Academic Press.

5. Evenari, M.L. Shanan, N. Tadmor, and Y. Aharoni. 1961. Ancient agriculture in the Negev Science 133 : 979-96.

in Israel. There is shortage of trees and shrubs for fuel common practices of use of gas or kerosene in new settlements is started. They have initiated the policy of planned settlement for Bedouin with all modern facilities and services to reduce semi-nomadism in the area. The first planned Bedouin village in the Negev was Tel Shiva established in 1968. Other villages are now being established with the coordination of local tribes.

Negev Desert is poor in major natural resources but still there are severe mining operation and Industry playing the role to support the people-government gives incentives to investors who placed their manufacturing facilities in developing town of Negev included grants, long-term low interest loan, training, tax advantage.

The Desert continues to be the subject of some of Israel's most intensive research activities. The broad spectrum of areas under investigation extends from basic studies on desert ecology, physiology of the desert plants and animals, and desert soils to more immediately applicable subjects. Such as mineral exploitation, agricultural practices and desert architecture. A far better understanding of desert ecosystems has been obtained, and it will undoubtedly aid in preventing or mitigating environmental degradation in this dynamic development area. This knowledge will also aid in the national development of the desert's nature resources - Results of these research projects have already been applied in the Negev economy. Some outstanding examples are faced in field of Agricultural research and in such areas as water desalination, mineral exploration and industrial development.

4.2.1 Desert Management in Israel - Magnitude and achievement

The Israel has adopted the integrated planning for the management of land, soil, water, Agriculture, cropping system, etc, to combat the desertification in the country. We can categorize the technological development in following parts.

(1) Catching and Storing Run off

(2) Harvesting Run off from Hillsides

(3) Run off farming

(4) Farm units and small watersheds

(5) Harnessing the floods

(6) Tapping Ground water

(7) Crops and cropping

(8) Irrigated Agriculture

(1) Catching and Storing Runoff - The major source of water in the Negev, has always been the surface runoff of winter rains Runoff can be gathered in either of two ways : directly-by intercepting and concentrating the water trickling off the slopes, before that water reaches the natural creek beds and accumulates to form a flood, and indirectly - by tapping

or diverting the natural floods after they have formed. They collect and store the runoff in the cisterns,[6] which are artificially constructed reservoirs of potable water, filled by directing surface flows during rainstorms. Cisterns are a common and time - honored means of supplying water to humans and livestock throughout the Near East. The city of Jerusalem, for instance, was sustained for many centuries by underground cisterns, hewn in the bedrock and fed by runoff from roofs, courtyards, and streets. The earliest cistern were probably imitations of natural water-holes, which are hollows in the beds or banks of wadis where small pools or puddles of water remain after each flood. The desert dwellers discovered early that they could obtain some water, at least for a short time, by simply digging or chiseling small pits or depressions in place where runoff accumulated naturally. Such cisterns were obviously inefficient, because they were subjected to rapid seepage and evaporation losses than the technique of `burning' lime to make cement and plaster was discovered to line the walls and bottom of their artificial water holes with close fitting stones.[7]

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6. Kedar Y. 1957. Water & soil from Negev, some ancient achievements in the central Negev. Geog J. 123 : 179-187.

7. Rawitz, E. 1973. Runoff collection and utilization in the Negev of Israel. In Physical Aspect of soil water and saets in Ecoryscom. pp.315-24, Berlin, Springer-verlag

Among the earliest of the cisterns found in the Negev are the open-pit cisterns, these were built by digging a roughly hemispherical pit in the soft marl to a depth of 4-5 meters, than lining it with stones and constructing steps leading down to the bottom. Water was directed off a hill-side via a single channel or several converging ones to a stilling basin, where some of the silt would settle out, allowing the partly cleared water to enter the cistern. Big boulders were arranged around the lip of the cistern to form a protective circle and to prevent the sediment-ladder "fresh" runoff water from flowing directly into the cistern without depositing at least some of the sediment in the stilling basin, which needed to be cleaned out periodically. To prevent pollution, minimise evaporation, and maintain safety, it was covered with some sort of rooting, weather planks or branches or cloth forming a tent.[8]

Next advance in cistern construction involved the technique of cutting and quarrying into bedrock., these were formations of the hillsides, their roots, walls and floors formed of the bedrock itself. Wherever possible, the cistern makers of antiquity shunned the fissured, hard limestone formations, in which quarrying was difficult and repeated heavy plastering was necessary to seal the cracks.

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8. Kedar Y. 1967. Ancent Agriculture in the Negev. Jerusalem : Bialik Instute (Hebrew)

To minimize evaporation, each cistern was generally given only two openings, one for water to enter and one for water to be withdrawn. Runoff was directed to the cistern via collection channels, which often led to a stilling basin, the overflow of which entered the cistern proper. The opening for the withdrawal of water was often marked by grooves, cut into the stone facing of the hole by the repeated friction of the sliding ropes that served to raise brimming jars of life-giving water.

Where cisterns were situated along the rim of a natural water course, they were filled directly with the flood water, rather than with runoff collected from the slopes through constructed channels.

Soon the tractors came. Across the hills and valleys, regardless of obstacles, they dug a trench and laid a black pipe with in it and then water was a problem no more. Where a small container was once the role source of water and the precious fluid was used ever so sparingly, faucets could now be turned on at will. No longer did the territory and its wadis and cisterns seem to matter so much, and the back-breaking task of restoring old cisterns became irrelevant.

The misgivings came only later. At the time the arrival of the pipeline seemed on unqualified blessing. The climax of ceremony was to be the turning of the tap to start the sprinklers, the sprinklers burst forth with glistening jets of Jordan river water brought from incredibly far away, shooting it into the clear desert air.[9]

The use of cisterns as a major source of water in the Negev seems-for the moment, at least-to have been superseded by importation of water pumped and piped from afar, these still remains the proven fact that the old cistern can if necessary, be made operational just as they were in ancient times. And what with increasing pressure of population and economic development, and the increasingly acute shortages of water and energy, the principle of storing runoff water in cisterns remains a sound one that may yet become economically feasible once again. And if again the cistern were to build, it would certainly the modification of past experiences, but the more difficult problem in the desert is the prevention, or at least substantial reduction, of evaporation Monomolecular films, formed from such substances like hexadecanol, though much touted years ago, are easily broken by wind and become ineffective on exptensive open bodies of water. Floating rafts or beads of styrofoam have been tried and various other techniques are under investigations. For the time, the simplest technique to filling the reservoir

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9. Evenori, M. 1971. The Negev : The challenge of a Desert. Cambridge, Mass. Harvard University press.

with coarse gravel or stones. This will effectively minimize evaporation - but also reduce the storage volume by as much as 60 percent. Perforated pipes can be laid at the bottom of the reservoir, and water can be drawn either by pumping or by gravity, depending on the topography.[10]

(2) Harvesting Runoff from the Hillsides -

The Negev dwellers did more than merely gather runoff - they actually devised an ingenious method to induce more of it, by clearing the stones off the slopes and thus smoothing the surface and exposing the finer soil to facilitate the formation of a self - sealing crust.[11] (Tadmor et al 1958, Hillel 1959) induce Runoff.

The hillside of Negev are covered with loose stones and gravel fragments partly embedded in soft soil, the exposed tops of the stones and fragments constituting an almost continuous surface called "desert pavement". This natural gravel mulch increases the infiltrability of the soil and slows the overland flow of water down the slopes, thus

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10. Thomas, G.W and T.W Box, 1969. Social and Ecological implecations of water importation into arid. In Arid Lands in perrpective pp-363-74. Tuscon University of Alizone Press.

11. Tadmor, N., M. Evenari, L.Shanan and D. Hilled. The ancient desert agriculture of the Negev. I Gravep mounds & gravel strips near Shivta. Ktavin Record Agr. Res. Sta. Rehovot 8 : 127-51.

hindering runoff.[12] When the loose gravel is removed, the fine, loess like soil beneath is laid bare and subjected to the influence of pelting raindrops. Being an unstable soil, the loess like material solves down to form a surface seal that markedly reduce the rate of water absorption (that is, the soil infiltrability) clearing a slope can cause greater runoff, as the result of greater runoff, the amount of erosion is also increased which is unavoidable but the act of clearing stones and of smoothing and compacting the surface could have been repeated from time to time to induce runoff.

The additional impregnation of exposed soil with material which can both seal and water proof the surface against infiltration and stabilize it against erosion results much more with modern technology to 70-80 percent of rainfall as induced rainfall even 100 percent of rainfall as induced rainfall. 100 mm of rainfall on just 1 square kilometer constitutes hearty nearly 30 million gallons of water of the highest quality.

In some desert regions, especially in high-attitude plateaus far from the sea, even allowing for the cost of land preparation and surface treatment, the inducement and

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12. Hillel, D. 1974. Infiltration and Runoff as affected by soil conditions. Hebrew University Faculty of Agricultural Research Report. Rehovot, Israel.

collection of runoff is already far more economical than desalinization and conveyance of sea water, once held to be the ultimate solution to the problem of water supply in arid regions.

The importance of runoff inducement (known variously as water harvesting" or milking the hillsides) is greater than mere increase to start runoff, this decrease the threshold correspondingly increases the problem of obtaining sufficient runoff. The simplest approach to runoff inducement is to cover the surface with an impervious apron of plastic, metal or concrete but the problem of this approach are how to make the covering materials adhere permanently to the soil surface, which may be irregular and have jagged protruding stones, and whether such materials can resist weathering.[13] An alternative approach is to cause the soil itself to shed, rather than absorb, the rain. In general it is possible to classify soil treatments for runoff inducement as follows: a) mechanical treatments - such as clearing stones and smoothing and compacting the surface, b) dispersive treatments-to enhance the self sealing of the soil surface, c) Hydrophobic treatment-to reduce the netta-

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13. Rawltz, E, 1975. Water harvesting by runoff iducement for irrigation In Proc. Water symp. Phoenix, Ariz. ARS W.22 USDA.

bility of the soil surface, the way fabric raincoat are treated to make them water-repellent, d) surface binding treatments-to permeate and seal the soil with an adherent material that can cement the loose soil into a firm matrix, e) various combinations of these treatments.[14]

The result of the comprehensive study have proved the effectiveness of the following methods for treating arid zone soil to collect runoff, eradication of vegetation and removal of surface stones, to reduce interception of rain and obstruction of overland flow, and to permit the formation of a continuous surface crust, smoothing of the land surface, to obliterate surface depressions and prevent water retention in puddles, compaction of the top soil layer, to reduce its permeability, by means of smooth roller at optimal soil moisture content, dispersion of the colloidal clay that is present in finer-textured soils, by means of sonic salts, to cause self-sealing and self-crusting of the soil surface, impregnation of the surface with sealing, binding, and hydrophobic materials, the most promising of which are solution or emulsions of asphalt and of silicone water repellents. All these methods depend upon the local condi-

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14. Rauzi, F.M.L. Fairbourn, and L. Landers, 1973. Water harvesting efficiencies of four soil surface treatments. J.Range Mgt. 26 (6) : 399-403.

tions, requirements and alternative possibilities.[15]

(3) - Runoff Farming - Runoff farming is a technique used in semi-arid lands where by rainfall which fails to infiltrate the ground is channeled into specific sites where it can accumulate as surface water or seep into the soil. In a dam or reservoir, runoff farming is based on series of micro-catchments in which rainfall from a small area is harvested and directed to a ditch or shallow pit, in which or near which crops or trees can be planted to take advantage of this additional moisture.[16]

(a) Nigarin System :- These are the important features of Runoff farming practiced in Israel. Much research has gone into the hydrogical planning of runoff farming system. This was implemented on a larger scale at the Mishash Farm at the beginning of the 1970's where the Nigeria[17] system of micro catchments was used and subsequently recommended elsewhere. Under this system, each tree has its own individual catch-

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15. Hillel, D. and P. Berliner. 1974. Water proofing surface zone soil aggregates for water conservation. Soil Sci. 118. 131-35.

16. Shanan, L. and Tadmor. N.H (1976) Micro catchment systems for Arid zone devit Hebrew University and centre of International Agriculture cooperation Ministay of Agriculture, Rehovot, Israel.

17. A "Nigaria" microcatchment. Showing the slope towards the pit and the 40 cm is deep pit. The tree root is drowsed when the pit fills with run off water. Pitls are spaced at 400-600 metres abort.

ment which is designed to supply an adequate amount of runoff water for survival in very dry years and growth in years of plentiful rainfall.

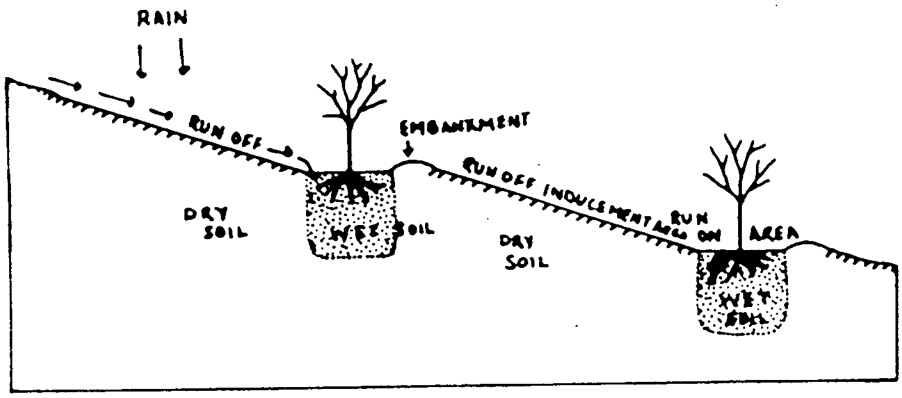
(b) Site of Planting : If earth dykes are used to collect runoff water, the water stays at the bottom of the dyke and the adjacent soil is moistured by capillary rise. The best place to plant the tree is therefore immediately above the water level or on the top of the dyke where the topsoil is now found.

Another important point is that the cultivation is done in the intervals between floodings as soon as the soil dries out sufficiently and the area above the high water level can be cultivated sooner than the area which has been flooded.

(c) Contour Dyke System :- The aims of run-off farming are four fold : second, to be able to plant the trees close enough not to waste time and energy on traveling between widely-spaced trees, third to be able to use animal draught or even tractors on orchards which are large enough for a full day's work and lastly to ensure that variability in runoff percentage is taken into account so that each tree will get roughly its due share of water.

d) The needs of the Farmer :- The fields where run-off farming is practiced may be for from the homeshead. These fore the size of the field should preferably be large enough

Fig No. i



Run off inducement and utilization on sloping land, by a series of alternating contour strip; runoff contributing strips, treated to enhance runoff; runon receiving strips, serving as cropland to merit a full day's work or too much time will be wasted on walking.

Economics of Run-off faring: To ensure the best return on the labour and capital inputs of type construction and maintenance the tree species selected were-those which gave direct benefit to the farmer in the form of an marketable produce e.g. alive trees for oil and picking; grapes and figs which can be sun-dried and stored; or almonds which yield protein-rich nuts. All these provides insurance against recurrent drought by yielding fruit even in dry years.[18]

The aforesaid techniques in the run-off farming in Israel have done well. They are not only technologically feasible but economically viable too. Most of the trees or crops grown there also carry sufficient amount of calories of energy for the farmers. The net return in terms of energy peer hecture or per tree is quite substantial than India.

(4) Farm units and small watersheds- Rainfed farming has long been practiced in the northern Negev, and irrigated farming with imported water is now carried out in the north-

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18. Shanan, L. and Tadmor. N.H. 1976. Microcatchment system for Arid zone Development. Habrew University and centre of International Agr. cooperation. Ministry of Agr. Rehovot. Israel.

ern Negev and even in limited locations in negev highland. In past all farming in the present subregion has depended on runoff utilization. This as a fundamental fact that near bears repeating, for it implies far-reaching corollaries. in this type of agriculture, runoff water from winter rains falling on adjacent slopes was gathered and directed to bottom and fields for periodic flooding, in order to accumulate and store sufficient moisture in the soil to produce crops. Although the average winter rainfall in the Negev is only about 100 mm, the settlers were able to gather sufficient runoff from the barren slopes to develop intensive agriculture in the depressions and bottom lands.

The ingenious type of direct agriculture has been called runoff farming. Whereas the farmer is more humid lands aims to soak all of the rain into the soil and thus present runoff, the desert runoff farmer of old worked on the opposite principle, his aim was to prevent the rain from penetrating the soil on the slopes so as to produce the maximum possible runoff. He than collected this runoff from a large area of slopes and collected it to a small cultivated area in the bottom lands. In this way he was able to raise crops even under adverse desert conditions.[19]

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19. Tadmor, N.H. 1970. Runoff farmengin the desert. IV. Survival yields of Permnial range plants. Agron. J. 62 695-99.

To manage a run off form, given the vagaries of rainfall in the desert and unpredictable nature of the water supply pattern with in and between seasons, a farmer would be required to maintain apparitional flexibility and to be able to make quick adjustments to varying circumstances. In wet year the farm as a whole would probably experience an excessive supply of water and it would be necessary to discharge the surplus downstream while preventing erosion. In dry years the amount of runoff collected could be insufficient for all the fields on the farm, so the operate would have to decide how to utilize the limited amount of water available most efficiently. Providing water to some fields while denying it to others be best strategy, depending upon the selection of crops.

Present day agriculture experience has shown that at least 250 mm of water are required, over and above the average precipitation of 100mm, to ensure a successful winter crop in this region. For 25 units of catchment to provide 250 mm of water, each unit must yield about 10 mm or 10 percent of its seasonal rainfall of 100 mm.

The use of conduits to divide the sloping ground into sub-catchment had the practical effect of preventing runoff from accumulating to form uncontrollable flash floods each conduit, collecting water from a section of slope not much greater than 1 hectare, delivered a small stream of water that could be handled and if necessary, diverted from one terrace to another or directed to individual trees, by one or two operates using hand implements.

The cultivated area of each farm unit was sub-divided into terrace fields. Each field was defined along its longer (down stream) edge by a level, step like retaining wall, or dike, partly embedded in the ground and protruding about 10 cms above the soil surface. The function of each dike, built at right angles to the natural gradient of the wadibed, was to spread and impound some of the flood water on the field, where the water could soak into the ground and be retained in the soil in a form available for subsequent use by crops, and to allow the excess water to flow down-stream in a controlled manner.

It is possible to utilize the land in a modern system of run off farming, in which a section of the land is shaped and treated for runoff inducement while another section receives the runoff so produced. Run off irrigation may be carried out either immediately, with runoff water flowing directly onto the section serving as crop-land, or water can be stored for future use in reservoirs. Although the former method is less expensive, its is also less flexible became irrigation is applied immediately following precipitation regardless of whether the root zone can effectively retain all the water applied.[20]

Several systems have been tried with respect to size and arrangement of the contributing area in relation to the water-receiving area. A small natural watershed can be treated in its entirely so as to provide the maximal amount of water that can be conveyed to irrigated fields. On a smaller scale, sloping land can be divided into more or less parallel contour strips, with alternating pass of strips treated to shed runoff and to receive it. Micro watersheds are the third possible approach, where in each tree or small plot of crop is associated with an individually tailored, artificial separated catchment (Aase 7 kemper 1968). Counter strip method, proved that in a region of 200-250 mm annual rainfall, almond trees can be sustained with contributing to receiving area as low as 3:1 (run off to -run on).[21]

(5) Harnessing the floods Modern engineering offers possibility for control and utilization of run off from medium size wadis, the construction of dams designed not to retain

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20. Hillel p. 1967. Runoff Inducement in Arid land. (Hebrow University Faculty of Agr. Research Report. Rehovot Israel.

21. Hillel D. 1974. Infiltration and Runoff as Aftectedby soil conditions. Hebrew Universtiy. Faculty of Agr. Reserach Report. Rehovot Israel.

the floods but merely to detain and regulate them so as to provide farms located downstream from dam with controlled flows. Such dams called detention dams, are built across a wadi in order to temporarily impound the entire flood, A large diameter open pipe is laid through the dam to permit downstream flow at a predetermined rate, as though the drain of a bathtub.

Thus, a flood lasting perhaps several hours is temporarily impounded and made to flow through pipe and into the field for perhaps several days. The field dikes are built economically and safely to withstand known flood intensities, and farming operation can be planned to handle the floods. eg. dam system on Nahal Haroah 1955.[22]

The construction and operation of a detention or diversion system in any given wadi are affected by upstream watershed conditions (size and character of catchment, amount and pattern of rainfall) and in turn, affect water supply conditions downstream. It is therefore utilize wadi floods efficiently only on an integrated basis. Wadi development cannot be carried out in isolated spots, but is coordinated in an overall watershed management programme.

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22. Lowdermilk, W. C. 1958. Floods in the desert. In proc. Symp Des. Res. pp. 361-374. Research Council of Israel Jerusalam.

The smallest of wadis, such a program, require regional coordination and administration.[23]

(6) Tapping Ground Water Waters originating elsewhere may also enter a desert as a ground water following in aquifers, Water contained in an aquifer may desire from an earlier and more humid geological period, and while usable, is irreplaceable under the present climates regime. Such 'fossil' water is known to exist to some extent in the sandstone formations underlying the Negev. However, these deposits are generally hundreds of meters deep and in many places of rather poor quality (breaking), so that their utilization, even given our present day technology is questionable.

Usable ground water occurs are relatively few, and the amount of water that can be tapped are scanty. Yet in antiquity the inhabitants of the Negev were able to locate many of these places and find the means to tap them. They faced so many of the spots where perched water table exists in the Negev. It is due to some practical knowledge of the Sciences in hydrology & geology.[24]

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23. Hillel, D. 1970. Artificial inducement of runoff as a potential sources of water in arid land. In Food, Fiber and the Asid Lands. pp. 323-330, Tuscon, University of Arizona Press.

24. Dixey, F. 1962. Geology and geomospshology, and ground water Hydrology. Arid Zone Res. 18-23-52.

Negev learned to line and reinforce their wells, and to locate them on higher ground alongside the wadi rather than in the stream bed. Such wells, tapping shallow ground water recharged by flood water, are found in a number of locations in the Negev. In some places the seepage from the wadis may be sufficient to permeate porous rock formations that can serve as aquifers. In such places deeper wells can be drilled into the bedrock, and the supply obtainable is likely to be perennial that is more steady and dependable and less affected by seasonal variation of precipitation. This type of wells are common in Northern Negev

There is ganats system in which it is to tap fresh water and convey it by gravity to irrigable land above the valley floor rather than depend on the naturally emerging, saline water at the bottom of the valley.[25]

Thus it can be concluded that ancient desert civilizations were adapting to the potentialities of each location, and in learning to find and utilize ground water even where it is scarcest. Over the greater part of the Negev however it is runoff rather than ground water that constitates the principal source of water for people, livestock and crops.

(7) Crops and Cropping Physical and technical aspect of

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25. Butler, M. A. 1933. Irrigation in Persia by Kanats. Civil Eng. 3 (2) 69-73.

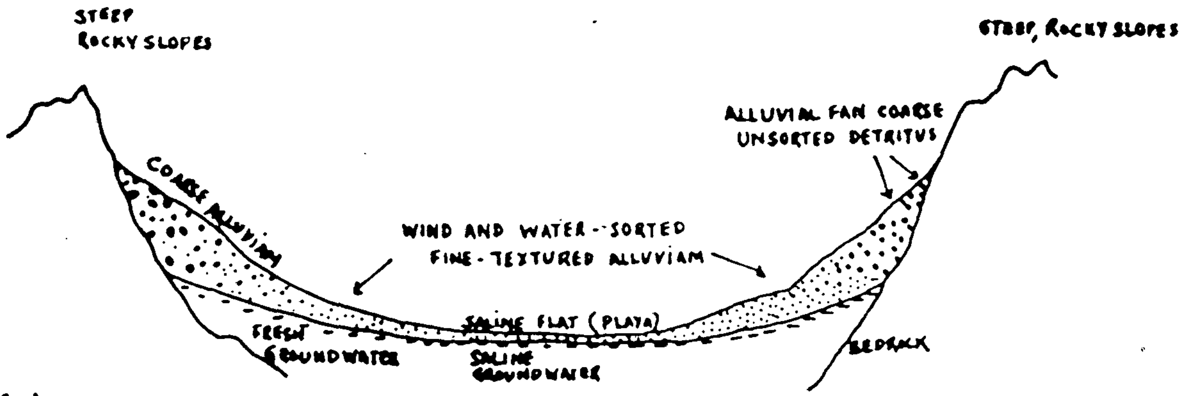

Fig. A

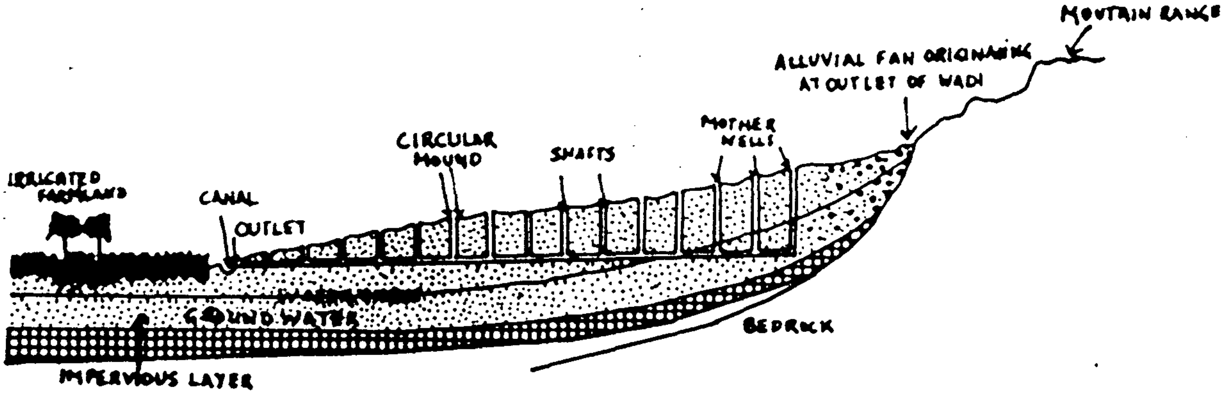

Fig. B

A. Cross section of an intermonate basin in the desert

B. Cross section of a qanat system. The fresh groundwater is intercepted in the alluvial fan by means of mother wells. The fresh water is thus tapped is conveyed by gravity through a gently sloping tunnel, which emerges at the valley floor and delivers watter to irrigable farmland.

desert agriculture and its modern extensions. But of course dikes and conduits, wadi diversions and spillways do not themselves supply food they are ingenious means to achieve the practical aim of food production.

At first we discuss the practices of the Bedouin to go by. The Bedouin who took over the land their sedentary predecessors also adopted some of their basic methods. From numerous they started flood-irrigated land or run off farming they raise seasonal field crops as well as fruit fresh in humorous patches of runoff-receiving land., and yet in them one find, intermixed such varied trees as almonds, apricots, figs, olives, and pomegranates; grapevines, and occasionally date palms. The principal winter crop is basely, but occasionally the Bedoiun plant wheat or legumes (Peas)

If the rains are delayed and the first effective ones do not come until it is too late for a winter crop, the Bedouin may prepare the land for summer crop to be planted in the spring, by plowing to eradicate the weeds and to conserve soil moisture. Before the time for planting summer crops, one can ascertain the amount of moisture accumulated in the soil by the winter rains and their resultant runoff, and on this basis decide whether indeed to plant a summer crop and which one. The most common summer crops are again-sorghum, various cucurbits (such as melons), and tobacco. Modern farming in the Northern Negev (rainfall 250-400 mm per annum), using improved varieties and fertilizers, produces much greater yields that is over twenty times the amount planted. Which is not comparable with ancient runoff farming. With only 51 mm of rainfall, they able to produce runoff and yields were 1210 kg of wheat and 1540 kg of barley per hectare which is slightly over eight and ten times, respectively the quantity of seed planted.[26]

Some seeds were discovered with papyri in one of the time-sealed rooms of a monastery in Nessana. Most of the seeds were identified as weeds, but some were of the crops mentioned in the Papysi. While these trusts may have been imported, it seems more probable that they were grown locally.[27]

Recent experiments with these species as well as with others, conducted under runoff of irrigation conditions in the northern and Central Negev, proved that these trees can indeed throne locally, and produce satisfactory yields Peaches, almonds, figs, and pomegranates are particularly

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26. Hillel, D. 1969. Soil-Crop Tillage Interaction in Dry Land & Irrigated farming Hebrew University, Faculty of Agriculture Research Report. Rehovot, Israel.

27. Kotler, D. and M. Negbi. 1966. Germination of seeds of Desert Plants. Project As10-Fs6. Hebrew University of Jerussalem Israel 24.

noted for their drought resistance and hardiness. In experimental orchard of peaches, apricots, plums and almonds, planted in a terraced section of Nahal Haroah near Sdeh-Boker developed beautifully for several years; however it had been provided with some supplementary irrigation.[28]

Efficient runoff inducement and utilization could probably ensure a minimally adequate supply of water in most seasons but some time rain often started late, or ended early, or their might be only one effective rain. All this made the growing of annual crops highly hazardous, while the growing of certain perennial crops, such as winter-dormant fruit trees was less so. Perennials are generally deeper rooted and if assured of a through wetting at least once each season, they can thrive even in a relative drought. The problem of the initial establishment and early growth of tender young Plants, encountered each season with annuals is less acute with perennials. Individual saplings could be given limited supplementary irrigation with cistern-stored water to ensure their establishment during the first reason or two, after which they would be expected to survive on the basis of collected runoff alone.

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28. Evenari, M. L. 1971. The Negar: the Challenge of a Desert. Cambridge, Mass. Harvard University University Press.

The production of annual crops tends to aggravate soil erosion. The act of flowing the land early each season loosens the unstable surface soil and makes it even more vulnerable to the erosive action of raindrops and of running water. This hazard exists in too perennial plantations as well, but to a lesser extent. The ancients quite evidently took great pains to avoid erosion in the fields, by controlling flow in conducts and by constructing sturdy terrace dikes and spill ways. At Sdeh-Boker Israel were successful in growing several species of summer crops in the Wadi bed of Nahal Haroah even after the drought Winter of 1954/55 ago, entirely on the strength of that season's single flood, which had occurred in early March. They did still better during the following two summers,.[29] The summer crops grown successfully on winter flood water irrigation included grain sorghum, sunflowers, corn, watermelons, other melons, squash, cucumbers and even tomatoes.

(8) Irrigated Agriculture Negev's principal agricultural activities were rainfed farming in the semi-arid northern plains, run off farming in the arid northern highlands and their foothills, and grazing throughout the region. Regular irrigation developed in ancient times in the Near East'

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29. Hillel, D. 1954. Summary of the 1953/54 growing season in the Negev highlands. Hassadeh, 34: 249-60.

river valleys, was practiced in the Negev only on a very limited scale. Where the ground water of alluvial fans could be tapped by means of clain-well systems. Now a days in contrast, irrigation has become the Negev's major method of agriculture. In 1950 the extent of irrigation in the Negev was only 880 hectares out of a total cultivable land area in the Negev estimated to be 44,200 hectares. By 1975, however, the cultivable land area in Negev had been increased to over 120,000 hectares, of which 30,000 were under irrigation. In short, the irrigated area in the Negev had been increased 34 times.

This rapid development illustrates the important role of irrigation in the modern agricultural development of the Negev. The principal site of this development has been the northern plains sub-region, where over half the land area is arable and potentially irrigable. This sub-region is also fortuitously, nearest to the sources of irrigation water, which are in northern Israel. The other sub-regions of the Negev have a much smaller agricultural potential; less than 10 percent of the land area in the Negev highlands sub-region, and less than 1 percent of the Asara valley, is cultivable.

The development of intensive agricultural based on irrigation in the Negev resumed directly from the construction of Israel's National water Carrier, which diverted large quantities of water from Northern Israel to the Negev, with in the 20 year period from 1955 to 1975 the amount of water piped to the Negev increased more than fourfold, from 30 million cubic meters to about 125 million cubic meters, or 11.5 percent of the total amount of water allocated agriculture in Israel. Production ranges from field crops (such as wheat, barley, corn, sorghum, cotton, forage crops) and fruit trees (citrus, peaches, apples) as well as various speciality crops (such as ornamental flowers and medicinal plants). About 90,000 hectares, incidentally, are cultivated in the northern Negev in a system or rainfed farming without irrigation, mostly for gain production (such as barley and grain sorghum). However, although the area of unirrigated land under cultivation in the Negev is three times greater than areas of irrigated land, the former represents 18 percent of the total value of the region's agricultural production.

The geography of Israel is such that by far most of its water resources are in the north, whereas its major land reserve is in the south. At the outset of Israel's agricultural development, there was some deliberation and disagreement over the desirability of Inter-regional transfer of water. Some hard headed advisers pointed out that these is enough irritable land in the northern regions of the country and it would be much more efficient to utilize the limited water supply close to its source rather than transport the water over great distances and expand the energy to left it to considerable heights above its point of origin. Indeed the construction of National water carrier required a tremendous investment, not only in initial construction but in annual operation as well. It involves the collection of water from three principal sources of the Jordan River (over 200 meters below sea level at the sea of Galilee) of the shallow, unconfined ground water aquifer of the Coastal plain and the underlying deep, confined limestone aquifer that outcrops in the Galilean, Samaritan, and jurdean highlands.

Furthermore, the scheme involved the mixing the these waters for salinity control and their conveyance under pressure in closed conduits to nearly every region of the country including the northern Negev.

Israel has made every effort to conserve and utilize water as efficiently as possible and started with irrigation regime of low frequency, designed to periodically met the soil to its maximal "field capacity" and replenish soil moisture by making up the deficit to field capacity.

The conventional methods of irrigation such as water impoundment over the field or in furrows, or high intensity sprinkling have made difficult to test alternative methods of irrigation designed to continuously maintain an optional level of soil moisture in a well aerated and well fertilized root zone, because most of the conventional irrigation system s are more expensive to run at higher frequency. The new task is how to maintain soil moisture in the root zone at a high enough level to keep suction low while avoiding wetting the soil excessively, so as not to impede aeration, or leach out nutrients, or waste water and new irrigation methods had been developed by Israel in recent years that could be adapted to deliver water in small quantities as often as desirable, without additional cost for the extra number of irrigations. These methods melude

(a) Permanent installations of low-intensity sprinklers

(b) Subirrigation by means of porous tubes

(c) the technique of deep or trickle irrigation

Since a high-frequency irrigation system can be adjusted to supply water at very nearly the exact rate required by the crop, Israeli no longer depend on the soils capacity to store water. The consequences of this fact are far-reaching; now, new land, until recently considered unsuited for irrigation, can be brought into production. One outstanding example is sands and gravels, whose natural moisture storage is minimal and surface conveyance and application of water would involve inordinate losses by rapid seepage of water beyond the depth of rooting. Such soils can now be irrigated quite readily, even on sloping found without leveling, by means of a drip system, with high frequency irrigation the farmer need no longer worry about when available soil moisture is depleted or when plants begin to suffer stress. Such situations are avoided entirely. To the old question "when to irrigate?" the best answer might be "as frequently as practicable; daily, it possible." To the question "how much water to apply?" the answer is enough to meet the evaporational demand and to prevent salinization of the root zone".

In the technique of drip irrigation, also called trickle irrigation, water is provided to plants (even large trees) drop by drop, at a slow rate that can be regulated precisely to meet the water requirements of the crop. This method was developed in Israel and was first tried on a field scale in the Negev in the mid-1960s. It has gained widespread recognition, and is now being introduced into many countries. Although the idea itself is not new, what has made it practical at last is the recent development of low-cost plastic tubing and variously designed emitter fittings capable of maintaining a uniform discharge of water throughout the field, as well as a controlled rate of drop discharge through the narrow-orifice emitters with a minimum of clogging.[30] The application system has been supplemented by ancillary equipment such as filters, timing or watering valves, and fertilizer injectors. Field trials in different locations have resulted in increased yields of both orchard and field crops, perennial as well as annual, particularly in adverse condition of soil, water and climate. Drip irrigation has also been found to be suitable for green houses and gardens, and lends itself readily to labor-saving automation.

With drip irrigation it is possible to obtain favorable moisture conditions even in problematic soils such as course sands and clay, which are still ill-suited to conventional ways of irrigation. It is also possible to deliver water uniformly over a field of variable elevation, scope, wind velocity and direction, soil texture, and infiltrability.[31]

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30. Aligihury, F. K. 1973. Drip Irrigation, Practices and application Calif. Farmer 238. (12) 28a-c

31. Rawitz, E. 1975. Progress and problems of drip irrigation in Israel. In Proc. Int. Conf. on Drip. Irri. San Diego

Where salinity is a hazard, as where the irrigation water is somewhat brackish, the continuous supply of water ensures that the osmotic pressure of the soil solution will remain low near the water source. Further more, drip irrigation, applied as it is to the soil underneath the plant canopy, avoids the hazard of leaf scorch and reduces the incidence of fungal diseases. Since drip irrigation wets the soil only in the immediate vicinity of each emitter, the greater part of the surface particularly the inter-row area) remains dry, and hence less prone to weed infestation and soil compaction under traffic. In summation, properly managed drip irrigation offers an opportunity to optimize the water nutrient, and air regimes in the root zone.

Over all agricultural production in Israel has been increased 1000 percent with in a single generation, and much of that increase due to the reclamation and judicious management of land and water in the Negev.

CHAPTER - V

COMPARATIVE STUDY OF INDIA AND ISRAEL

5.1. **Comparison of technology inputs -**

Israel is a small and resource poor country and more than half of the land area is desert area, whereas India is a vast country having vast resources also and its desert area covers twelve percent of the geographical area.

In Israel the research and development wing innovate the new technology through which they reclaim their desert land, which was lying through a many centuries as a barren, wasteland. They developed the methods of land and, water husbandry through collection of runoff from slops, built terraces to conserve water and soil.

We are going to compare India with Israel in this chapter. So it is important to know the physiographic and climatic condition of both the countries the climatic condition is rather some what similar but the physiography and topography of the two counties is entirely different. So Whatever technological innovation is produced is based on both these two factors that is climate and physical condition.

The climatic condition is like this that Negev area has an extremely sharp rainfall gradient ranging from 400 mm is North to 100 mm is south the change of 4 mm per kilometer, a slight change in climatic condition could cause expansion or contraction of desert. Whereas in India it is general view that during 70s there was increasing trend of rainfall, but in 80s there again is the decreasing trend. We can say that in both the country the rainfall is inconsistent and there is a variation from decade to decade in rainfall.

Negev desert in comparison with Indian desert area is rather small, In Negev, over 90 percent of land area is consists of marine sedimentary rocks, primarily limestone and chalks of varying degree of hardness, the landscape is of rocky hills and mountains, gravel paved plateaus, coarse sediments and sands. There is few extensive tracts of potentially arable soil. The soil is buff colored, fine grained, wind borne deposits of desert dust having unstability of erosion by wind and water. Mostly the desert have mountainous area, only northern plain subregion of the Negev is Israel's main agricultural land reserve.

Whereas Indian desert is vast, covers 12 percent of the geographical area which is more enough as compare to 90 percent of Negev region in Indian desert. 60 percent of the it is covered with sand and rest is rocky in character which is incapable of producing a single blade of grass, the region embodies the geological formations ranging from the Archgen Banded Geneissic complex to quarternary older Aluvaian and blown sand covering wide tracts of Indian desert. (Map)-Page 63. RMD, There is a exception of the hilly a outcrops, which account for about 13000 sq km or approximately 7 percent of the area. There is expensive sand laden topography. high extremes of temperature and variability of rainfall place heavy impact on the socio-economic characters of the region and India has been facing this constant challenge to meet in adopting the activities to there conditions. Drought and famines are frequent and the arid condition are of long standing in the region(Sharma R.C. An overview Resource Management in Dryland pp.7).

Technology input comparison

(a) <u>Comparison of water management</u> - Because Israel has mountainous topography. They have developed techniques according to it, which includes catching and storing runoff, heater, Harvesting water from Hillsides, runoff watersheds etc. Mainly the winter rainfall is the only source of water in the Negev. A similarity has been found in relation to the water harvesting techniques, long before when the modern technology had not been developed. Dwellers and further improved certain water harvesting techniques based on traditional knowledge. Kundi in thar and cisterns in Nevev desert were developed to tackle the problem of drinking water by harvesting and storing rain water. Initially water collected from roof top, courtyards and streets was stored in cisterns, then the cisterns were constructed near hill slopes and water brought through constructed channels was collected in the former. Cisterns were also built along the rim of natural water courses where from flood water could enter the cisterns. With the advent of technology especially in the form of pipe lines that brought water from distant places cisterns have been rendered useless. On the other hand, kundis have been in used in thar desert till today. Water fromroof tops, courtyards and other pared spaces is collected in the Kundis. Since the problem of drinking water in desert has not been resolved completely, the Kundis are still resorted to for the storage of water for drinking purposes.

Apart from Kundis, one an other major system of water harvesting and storage existed in the desert cities eg. in Jodhpur. Catchment areas were developed ones the proximus hills and their slopes to harvest water in baoris the water was conected through constructed channels during the monsoon and was used for the rest of the month. Unfortunately, due to the urban expansion & quarrying in the aforesaid hills these catechments got destructed. Thus, an efficient system of water harvesting has been lost. They (Israelies) accumulate the surface runoff by intercepting and concentrating the water trickling of the slope before that water reaches the natural creek beds and accumulates to form a flood. By tapping or deserting the natural floods after they have formed. They collect and harvest the runoff in the cisterns. They also used technique of cutting and quarrying into bedrock, Harvesting the Runoff from Hillsides by clearing the stones off the slopes, removing loose gravel and induce the runoff from slopes. For seen off inducement they cover the surface with an imperious apron of plastic, metal or concrete; then soil treatment in 4 ways has done that is mechanical, dispersive, Hydrophobic treatment and various combination of these treatments.

In India water harvesting system is used in which runoff is collected from rain water and storing it in open water reservoirs or in the soil itself it is practiced in India with different techniques for different purposes. The conservation techniques have been tried in India are Interplot water harvesting for vegetables and fruit crops, Desert strip water harvesting and bench terrace water harvesting. Due to high temperature and evaporation the moisture contained by soil during rainfall is not present for longer period. The inter plot harvesting system is used for more soil moisture and for decreasing the probability of crop failure but large area has to be kept uncropped which is most disadvantageous factor. The selection of the water harvesting system is depends on the rainfall characteristics of the area. One system may prove better than other for a particular situation in the area of high scarcity of water, small ponds are constructed for storing the water. In addition to afore mentioned water harvesting technique, certain catchment water harvesting technique have been evolved for water management these include runoff management and recycling of runoff water. Runoff management can be done with techniques for inducement of runoff but these have been found to economically unafforadable due to lower incomes of the desert people. Efficient storage in resevior is other approach for runoff management. For recycling of runoff water furrow irrigation for crops planted in rows has been used. The major technology transfers have been made in the field of sprinkepers and drrip irrigation, again owing to unaffordability their adoption has found only a sporadic appearence.

It is analised that in Israel the mountainous topography helps the surface runoff in more volume and frequent due to its gradient and gravity factor where as in India collection of water is rather more difficult to channelised into particular area. The hardness of the rock in Israel cause less penetration of water into soil and there is more chance of collecting and channelising water into one space. Where as in India the high temperature, more evaporation and more infiltration of water in soil cause more wastage of water rather than to conserve it.

In Israel contour Dyke system is successful in harvesting the high percentage of rainfall. Modern engineering helps in to control and utilization of runoff from medium size wadis, construction of dams to regulate water to farms in downstream. In Israel there is management practices done under whole watershed management programme which is directed and controlled very efficiently by administration of Israel government.

In India various programmes have been launched to combat desertification where as in Israel it was the dead goal of the Israel government to innovate new technologies to completely combat the desertification, and in Indian part there is lack of coordination between various agencies. In Israel, the practical knowledge of sciences in hydrology and geology helps in locating many of the aquifers, from where they can tap ground water easily. In India, also aquifers have been identified in many areas but sustainable utilisation hasn't been done.Due to high evaporation, the infiltration into deep soils has been less Low water table in the region has not giving any of natural aquifers whereas negev learned to live and reinforce their wells, and to locate them in higher grounds as well alongside the wadi rather than in the stream bed. Those wells, tapping shallow ground water recharged by flood water, are found in a number of locations in the Negev.

(b) Comparison in Agriculture, cropping system - In Negev rainfall farming has been practiced in the Northern Negev, the farming with imported water in also carried some year ago both in Northern and Southern and Negev highland. The Negev have average rainfall of 100 cm in which they were able to gather water from runoff and there takes intensive culture without any hindrance in the bottom lands and depression. The use of conduits in slopes helps farmers to control flash floods and this make them easy to divert water from one terrace to another or directed to individual trees by single operator. Other is slope is divided into more or less contour strips, with alternating pairs of strips treated to shed runoff and to receive it. Another approach is micro water sheds in which seperate catehment is made artificially to raise corps in small plot, these were the methods and techniques applied by Israel in their fields.

In India, on the otherhand, desert is sandy the integrated approach is needed to raise the crops in the field. India's Agricultural engineering plays good role in Indian arid zone, which includes, Tillage and seeding practices, soil and water conservation practices, desert strip (contour catchment) farming. The deep tillage of the field by new implements like to seed and fertilizer drill and Noble seed drill helps in improving yield; contour tillage in sandy parts of India helps in reduction of soil loss and helps in conservation of moisture. Since the desert in India recieves rainfall during the Monsoons spread over a few days, the availability of moisture is very less both temporally and vis-a-vis the amount of moisture. In such a situation, the sowing task needs to be completed in short span of time i.e. when the moisture is available tractors have been found to be extremely useful to carryout the plowing and sowing in a time efficient manner.[1] Desert strip farming is often tried in hill slopes. Another approach in India in farming system is inter-cropping system is which two or more crops grows on the same piece of land so that if one crops fails to grow, another crops helps the people to sustain this technique was used early in Indian desert because it reduces the probability of total failure of crop, but his helps in all the soil fertility level. Where as in Israel the former is sowing

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1. Dahiya Bharat 1996. Macro Habitats in Arid Zones: development-environment interface. <u>SDR Planning and development for desert areas</u> Vol. 3, No. 1, Jan.-Feb. 1996. pp. 43.

seeds according to the situation and by testing the soil moisture, if soil moisture is not enough they prepare the land for summer crops, this was the practice used by Israelis in early times.

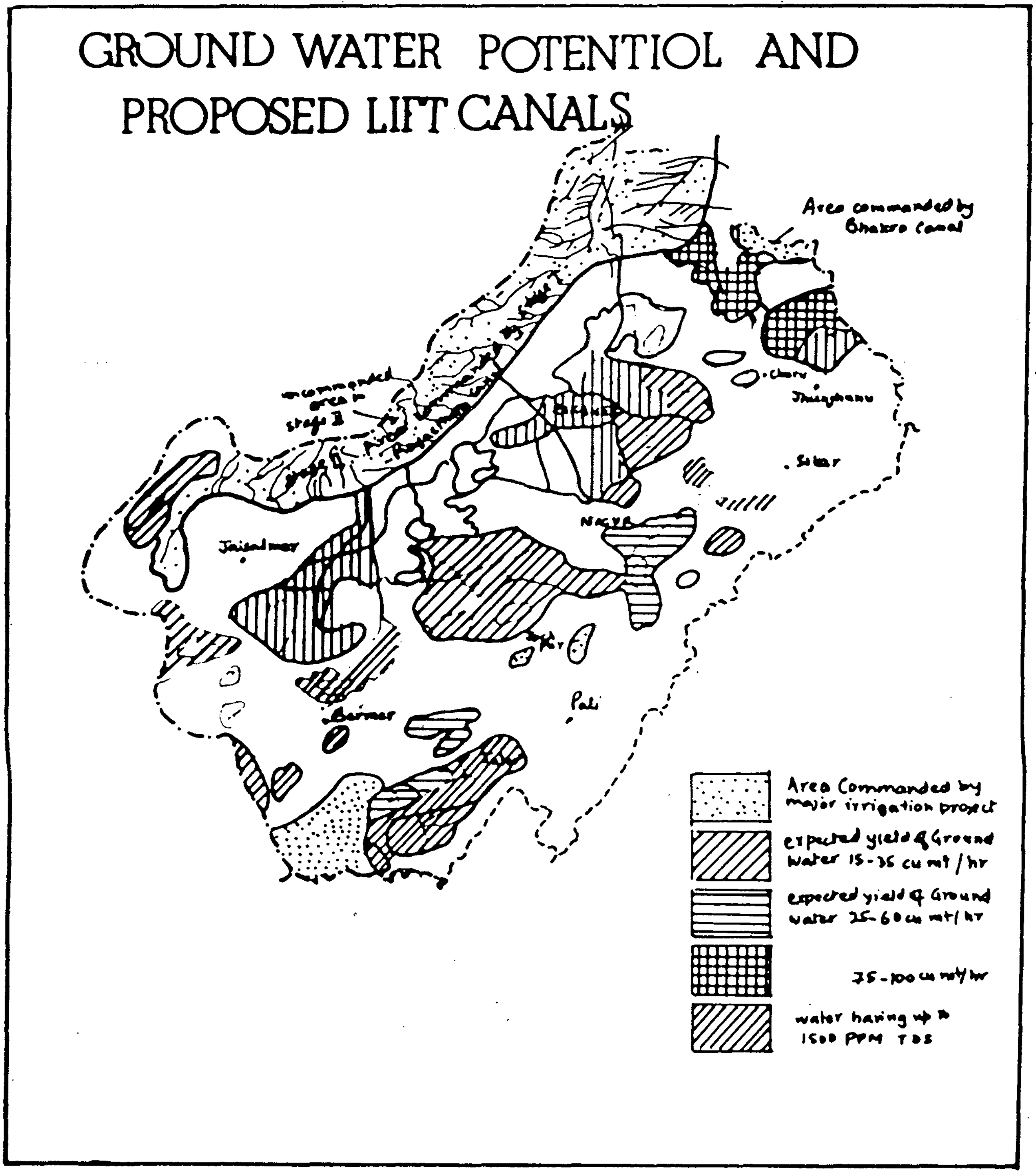
However, they had started the intermixing of varied tree species. In Israel if winter crops in failed, it is summer crops which is grown successfully. In Israel the principal field crops are wheat, barley, corn, sorghum, cotton, forage crops; the vegetable crops are potatoes, tomatoes and fruit tries are cirtus, peaches and apples the peaches, almonds, figs and pomegranates are particularly noted for their drought resistance and hardiness. And in India the principal crops of the arid zone are Sorghum, Pearl millet, Groundnut, Pulses, Chickpea, Maize, Cotton Rape/Mustard, Rice, Barley and Wheat.

Irrigated Agriculture : - In India, the major irrigation methods are through canal irrigation, wells and ranks. In Indian Desert 20 to 50 percent of water is lost during conveyance from source to the field in different soils due to seepage and percolations losses. Lack of sufficient available water in the root zone during periods of crop growth is of common occurrence in dry farming areas. These is traditional methods of irrigation like flood, check basin, border irrigation, which are of little consequence as losses are high and utilization is low. During long dry spell the stored runoff water have been applied to crop by efficient method of irrigation are tried is some parts of India like furrow irrigation, sprinkler, irrigation and drip irrigation. The methods are efficient but are very uneconomical to Indian situation however, the sprinkler irrigation is becoming increasingly popular in India because it is most suited to Sandy soils but the limitation with the adoption of this system is its higher initial lost for installation higher annual depreciation.

On the other hand, Israel had started irrigation, before that the ground water was be tapped, then the development had taken place in western plain subregion. In Israel the most of the water reserves are in north and land reserve is in the South although there is enough arable land in the Northern region of the country but Israel have made efforts to take water from north to south with all possible means. Then conventional methods have developed such as impoundment over the field or in furrows, or high intensity sprinkling, Drip irrigation was innovate which then introduced by many countries. Most interesting development in Israel is the development of intensive agriculture which is totally based on irrigation. Negev resulted directly by transportation of water from northern highlands through pipe to the southern Negev. This results in fourfold increase in water availability and irrigated land increased by 34 times which is a reminds achievement. But the point is that Israel have able to afford such a heavy task economically and the technology is capital-intensive, and the scientific development in that country was well in advance but India is not able to afford such a capital-intensive technology although with the help of would bank initiate the great step of cutting one of the longest man-made water ways in the world. It is not known about its environmental and economic effects will be. But it is fact that India tries its best to supply water in the most inhospitable areas on the earth. This canal is called Indira Gandhi canal. The thar desert is being transformed and vast man-made water system which is causing the change is a testament to Indian engineering skills. But the thar lacks a drainage system and excess water left after irrigation has the potential to create water logging in the canal area. There is danger of water logging and subsequent soil salinity which could grip with in a few years.

It is being noticed here that what the Israelis have done by transporting water from northern highland to Southern Negev is essential for the sustainability of their inhabitants and their main motive was to colonize the desert

Map No. viii


GROUND WATER POTENTIOL AND PROPOSED LIFT CANALS
Area commanded by Bhakra Canal
Churu
Sikar
Jaisalmer
Barmer
Pali
Area Commanded by major irrigation project
expected yield of Ground water 15-35 cu mt/hr
expected yield of Ground water 25-60 cu mt/hr
75-100 cu mt/hr
water having up to 1500 PPM TDS

area and due to rugged and undulating topography they have to innovate such technique (like pipe) through which they can transport their water to desert area where as Israel is small country and there are no large drainage system like in India. On the other hand India has plain sandy topography and there is vast drainage system available in India which makes Indians to dug canal (Indira Gandhi canal) to transport water for irrigation in the desert area. And according to Indian situation it is canal rather than pipe which is economically and environmentally more suited to irrigate land. However, India is using other techniques also.

5.2. Possible collaboration Between India and Israel for desert Management.

It has been observed in the preceding paragraphs that there are certain areas where collaboration for technology Transfer and Desert management is possible between Israel and India. It ought to be noted that both countries have put in innumerable efforts for the sustainable development of the natural resources found in their desert areas. The difference in approaches owes mainly to the geographical features of thar and Negev deserts.

Traditional Approaches -

To start with, both countries have had traditional water harvesting and storing techniques to tackle the problem of drinking water. Israel has given up the use of such techniques for she is able to provide drinking water to all her desert dwellers. In India such techniques are still in use and in near future the trend seems to continue. Hence, any kind of collaboration in this field would not be forth coming.

Modern Approaches -

(a) Possible collaboration in the Management of water:-

Major area of collaboration is that of water harvesting, run off management and recycling of runoff water. Firstly the technology of runoff inducement can adopted in India where the topography is rocky viz along the Aravallis, certain runoff inducement techniques have been evolved in India also but they are not applicable for large scale runoff inducement.

Here, the economics of adoption of such techniques should be taken care of for this will be a costly affair. India has also developed the drip irrigation technology but certain lessons can be learned from the technological development of drip irrigation in Israel. The Negev system of water harvesting (ie each tree having its own catchment) can be adopted for Indian situations. Moreover contour drip system can be adopted only after going into its technicalities.

Although India has well developed system of water harvesting through Khadins but the detentions dam approach for harvesting the floods could be examined and further adopted to temporarily impound the floods and to irrigate parched land for cultivation.

Possible collaboration -

(b) Possible collaboration in Management of Agriculture and cropping system :- India has developed, with help of Agriculture Engineering. certain techniques for Management of agriculture and cropping system in deserts, ideal tillage practice (use of seed arm fertilizer drip and Noble seed drill), contour tillage (contour bundings) machinery to prevent soil blowing, surface moisture barrier etc could be adopted by Israel for sustainable development of their agriculture. In the field of cropping collaboration may not be there because the rainfall characteristics of both these countries are totally different.

CONCLUSION

CONCLUSION

The present research has focused on Thar and Negev desert, their characteristics, the general process of desertification. The efforts to evolve technology and other scientific approaches and techniques and the transfer of all these, certain aspects of progress made and achievements. The comparison between the two countries efforts to transfer of technology and the possible areas of collaboration of such technologies.

The present study focuses on the Desertification process in India, and the various causes for its expansion towards south -eastern part of the desert. It is an international problem and it is a common placed interest of the world that how to use the resources of the earth to sustain the eco-system of the earth. In developing countries, like India, the people are too poor to afford the new technology, which are innovated by developed countries. So there is problem of transfer of technology from developed to developing world. Institutions like CAZRI (Central Arid Zone Research Institute) in India are given task to develop the new technology which can be best suited to the Indian climate condition and the social - economic structure of the area. In India, western Rajasthan desert covers 62% of the totals area of arid zone the desert is found to the spreading towards east and south east. The process of desertification owes to disorganisation of the drainage, scarce and scanty rainfall increasing salinity of ground water alarming increase of bovine population, and urbanisation and Industrialisation as a result 76.4% of the total area of Thar is found to be highly vulnerable to desertification.

Help of Resource Surveys, Atlases, Remote Sensing data, hydrological investigations and Research & Development has been taken to suggest technologies and other scientific approaches and techniques to address the problem of desert management in India. This include recognition of drainage system, proposals for mineral inputs and reclamation of lands. Hitherto unused, range bio-mass estimation development of techniques for sand dune stabilization, increased moisture retention, new cropping and irrigation, horticulture development and development of hybrid species for increased production in Thar desert.

India has made voluminous efforts to transfer technology for desert management, specific technology and techniques evolved relate to soil and land management of water, Management of Agriculture & cropping system and that of live stock. It has been found that general as well as site specific technology & techniques are available for sustainable utilisation & desert resources.

India also has an excellent institutionalised set-up for technology transfer K.V.Ks, trainers framing centres and extension farming infrastructure exits with ICAR (Indian council of Agricultural Research) as the apex body that imparts training. Technology transfer is actually done with the help of Agricultural Extension Agents and change agents who are supposed to know the problems is local context.

Israel's efforts for technology transfer have been guided by the combined objective of development and colonization of Negev desert. The techniques used for desert management include harvesting runoff from the beside farm units and small watersheds specially in the depression and bottom lands, harvesting of floods with the help of detention dams, tapping of ground water. Shift of cropping from winters to summers due to absence of effective winter rains, and development of irrigated agriculture by transporting water through pipelines from Northern to Southern Negev. In India the irrigation in practiced through canal because India have drainage system also. The canal is best suited to Indian situation because large tract of land is plain sandy area, and construction of canal in this area can be constructed easily where as in Israel the large part of area is rocky and mountainous they developed the water harvesting technique through pipes. The technology is used since 1975 and the Israel has made great task of converting the large desert area into productive area.

In Thar desert 20 to 50 percent of water is lost during conveyance from source to the field due to seepage and percolation. Since lack of sufficient available water in the root zone during period of crop growth is the main constraint for growth of crop. Since the Indian people use traditional method of irrigation, the loss of water is very much. But when we study about Negev desert we find that they take scientific steps and irrigation technology to use each drop of water. In Israel, although there is arable land in the northern region of the country but arable land in southern part but Israel has made very scientific efforts to take water from north to south at any coast. The most innovative method used in Israel for irrigation is high intensity sprinkler, Drip irrigation. Most adventurous development in Israel in the development of intensive agriculture which is based on irrigation.

About transfer of technology for Desert management India has good prospect from Israel. But main difficulty in is the socio-economic structure of the people and their under standing about it. It will be better for India to have an agreement for technology transfer for desert management. But it should be have time limit so that it bring better result.

So to get better result of desert management, Indian Government should work to provide better infrastructure, that can help small farmers for their change in socio-economic structure, upliftment in their standard of living by providing initial economic support and providing latest technology.

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