DESERTIFICATION CONTROL FOR IMPROVEMENT OF ENVIRONMENT AND SUSTAINABLE LAND USE OF CHOLISTAN DESERT – PAKISTAN

By

Muhammad Akram[1] and Zamir Ahmed Soomro[2]

Abstract

The area of Cholistan Desert is 2.6 million hectares. The length of the desert is about 480 km and breadth ranges between 32 and 192 km. Human and livestock population in the desert is 0.1 and 2.0 millions respectively. There is no river or canal flowing through the desert area. The desert area falls under hyper-arid climate. The main land use of the area is livestock rearing. The agricultural farming is not practiced due to non-availability of irrigation water and low rainfall. More than 81% area of the desert is under small and big sand dunes. While 19% area is consisting of alluvial flats and sand hummocks. The area is affected with severe to very severe desertification caused due to poor vegetation cover, severe wind erosion and very severe soil salinity. The grazing of livestock is uncontrolled, therefore, the pastures are overgrazed. The Pakistan Council of Research in Water Resources has converted the severe desertified land into productive land as a model on more than one hundred hectares in Cholistan through sand dunes fixation and stabilization by mechanical and vegetative means. The area once desertified is now under fully secured from desertification and its micro-climate has been improved into pleasant and friendly environment.

1. INTRODUCTION

Total area of Pakistan is 79.6 million hectares, out of which 70 mha fall under arid and semi-arid climate. While about 41 mha are arid including 11 mha of deserts. The main deserts in the country are Thar, Cholistan, Thal and Chagi-Kharan. These deserts are under severe to very severe desertification due to over and mis-utilization of land, water and vegetation resources without any scientific planning and management. Cholistan is a vast sandy desert spreading over about 26,000 sq. km. It is located between latitudes 27^{o} 42′ and 29^{o} North and Longitudes 69^{o} 57′ 32″ and 72^{o} 52′ 30″ East. The length of the desert is about 480 km and breadth ranges between 32 and 192 km. There are two parts of Cholistan called Smaller Cholistan and Greater Cholistan. Smaller Cholistan in the North is consisting of alluvial flats and low sand ridges. Whereas the Greater Cholistan in the South is covered with big sand dunes. The main source of good quality water in the desert is rainfall. The groundwater in the major part of the desert is highly saline. The mean annual rainfall in the desert is low, variable and erratic. Most of the rainfall is received in the months of July, August and September during monsoon season. The annual rainfall varies between 100 and 250 mm. About 1.13 million hectares of Cholistan is under big sand dune with rolling to moderate topography. The extent of sandy soils is 0.95 million hectares, which are nearly level to gently sloping with

1. Director General (DC), Pakistan Council of Research in Water Resources (PCRWR), Khyaban-e-Johar, Sector H-8/1, Adjacent Edhi Home, Islamabad.
2. Regional Director, PCRWR, Regional Office, Lahore

hummocks. These soils are deep to very deep, excessively drained, calcareous and coarse textured. The loamy soils are in the vallies between dunes in both parts of Cholistan. The extent of these soils is only 0.06 million hectares making 2% of the desert. The alluvial flats in the smaller Cholistan are consisting of mostly fine textured clayey soils. These soils are mostly level, shallow to moderately deep, poorly drained, calcareous and saline-sodic. The extent of these soils is 0.442 million hectares making 17% of the whole Cholistan. The vegetation in the Cholistan area is mostly xerophytic and halophytic consisting of bushes, grasses, shrubs and some very drought resistant trees. The land is not used for agriculture farming due to hyper-arid climate, low rainfall, topography and non-availability of irrigation water. The main land use of the area is livestock grazing and major source of income for the local people. Drinking water for human and livestock population is not available as per their requirements. As a result, the livestock production is less than its potential. Due to non-availability of drinking water for the whole year people migrate from the area alongwith their animals toward canal irrigated areas in search of water. They stay there till the next rainy seasons.

2. DESERTIFICATION

Desertification in the Cholistan desert is due to degradation of soil and vegetation cover caused by various factors. Soil and vegetation degradation are contributory factors to each other. The main desertification processes recognized in the Cholistan desert are; water scarcity, low rainfall, poor vegetation cover, wind erosion, soil salinity and very poor soil physical properties e.g. porosity, permeability, crusting etc. Climate is also one of the major contributors to desertification in the Cholistan desert. Dryness of atmosphere, sporadic and erratic rainfalls, high rate of evaporation cause reduction in growth of vegetation cover. As a result, bare soil is easily invaded by the wind erosion and causes land degradation leading to desertification. The extent and severity of desertification is given in Table-1.

Table-1: Extent and Severity of Cholistan

Desertification Class	Extent		Causes
	Hectare	% age	
Moderate	58700	2.0	Moderate sand migration due to wind erosion, vegetation cover above 30% and less than 50%, moderate soil salinity and hyper-arid climate.
Severe	2079400	81	Vegetation cover less than 30%. Area under big sand dunes, small sand ridges and hummocks, severe wind erosion and hyper-arid climate.
Very Severe	441900	17	No vegetation cover or vegetation cover less than 10%, saline-sodic impervious fine textured soils, pH more than 9.0, very hard soils, non porous and very poorly drained soils.

Total	2580000	100.00	

Source: PCRWR

Severely Desertified Rangeland

Very Severely Desertified Pasture

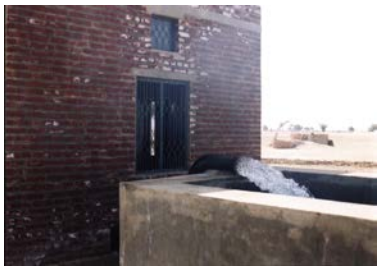
3. DESERTIFICATION CONTROL MEASURES

3.1 Management of Water Resources

Pakistan Council of Research in Water Resources conducted research on rainwater harvesting system and identified the potential of runoff more than 350 million cubic meter from average annual rainfall 160 mm in normal rainy years to develop water sources. To harvest and collect all estimated potential quantity of rain runoff, there would be need of twenty one thousand (21000) reservoirs. The water requirement for drinking of human and livestock population 0.2 million and 2.0 million respectively in Cholistan is about 8.0 million cubic meter. While the remaining rain runoff after meeting drinking water requirements can be made available for farming of precious vegetables and fruit trees in Cholistan to develop more economic resources for the social up-gradation of community.

A net work of water resources has been established by PCRWR in the Cholistan desert by developing specially designed 92 reservoirs at appropriate locations normally after 10 to 15 km each with water storage capacity of 15000 cubic meter (4.0 million gallons) making total of 1.35 million cubic meter (368 million gallons) from all reservoirs annually. Twenty specially designed deep tubewells have been installed by PCRWR with discharge annually about 7.0 million cubic meter (1405 million gallons) in the Cholistan desert where groundwater is usable for drinking of human and livestock population. Two Reverse Osmosis Plants have been installed to desalinize highly saline groundwater with desalination capacity of 0.01 million cubic meter annually for human and livestock drinking. The developed water sources have been distributed in the whole Cholistan desert considering population of human and livestock to meet the requirement of drinking water. Now drinking water in the desert is available throughout the year. As a result of water source development, migration of human and livestock due to shortage of water has stopped and loss of rupees 6 billion annually caused due to reduction in livestock production in the form of mortality, diseases, reduction in meat and milk as well as damage to crops in canal irrigated areas have been saved. Further, micro-climate around the reservoirs has also been improved friendly to life. Now birds and other

wildlife can be seen frequently around the reservoirs as well as more and new vegetation species can also be identified.



Deep Tubewell

Reservoir

Reservoir with Filtration Plant

3.2 Sand Dune Fixation and Stabilization by Afforestation

Livestock grazing is the major land use of these deserts. Grazing is un- controlled which results in a overgrazing which continues to decrease the vegetative cover. Stabilization of sand dunes with perennial vegetation cover is the only sustainable solution to halt sand migration toward irrigated fertile lands, to avoid their abandonment and to produce timber, fuel wood and forage for livestock. This will rehabilitate desertified land and protect it and surrounding area against desertification. The stabilization of mobile sand can be achieved by prohibiting free livestock grazing and by re-vegetation with drought resistant species of afforestation trees, grasses and shrubs. Shifting sand had been fixed by micro-barrier fences in the checker board form before plantation at Dingarh to create an environment for growth of plants successfully. These micro-fences had prevented the movement of sand for long enough to enable natural and planted vegetation to become established. Alternative irrigation with rainwater and saline water help the plants to grow fastly, therefore, it played important role in developing good vegetative cover to protect bare soil against the danger of wind erosion. The perennial tree species i.e. Acacia, Tamarix, Zizyphus, Parkinsonia, Prosopis, Ampliceps and Eucalyptus had been used to develop excellent vegetation cover on the mobile sandy area affected with wind erosion. The survival and growth data of trees is given in Table-2.

Table 2: Survival and Growth of Trees

Age (Months)	Zizyphus			Accacia			Eucalyptus			Tamarix		
	Surv-ival % age	Heig-ht (cm)	Can-opy cover (cm)	Surv-ival % age	Heig-ht (cm)	Can-opy cover (cm)	Surv-ival % age	Heig-ht (cm)	Can-opy cover (cm)	Surv-ival % age	Heig-ht (cm)	Can-opy cover (cm)
6	84	37	-	77	57	-	86	53	-	72	35	-
8	57	49	-	75	61	-	83	66	-	60	55	-
12	51	59	-	73	80	-	82	84	-	53	71	-
22	43	104	51	68	115	100	82	129	80	53	96	82

25	**43**	**118**	**82**	**66**	**131**	**126**	**80**	**149**	**101**	**53**	**106**	**112**
Average	**56**	**73**	**27**	**72**	**89**	**45**	**83**	**96**	**36**	**58**	**73**	**39**

Source: PCRWR

The canopy cover in the wind erosion affected area before and after plantation of tree species with interval period of 5 years and 12 years was measured and data for vegetation canopy is given in Table-3.

Table -3: Canopy Cover of the Dingarh Test Site Cholistan

Traverse No.	**Canopy cover in percentage**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Before fencing and plantat	10	14	15	22	18	25	32	26	27	27	20
After plantation of 5 years	85	75	90	96	96	93	90	98	92	95	90
After Plantation of 12 year	87	75	89	86	74	87	93	83	73	89	81

Source: PCRWR

Canopy cover before plantation was between 10 and 32 percent among the 11 traverses. Five years after plantation the canopy cover improved between 75 and 98 percent. After 12 year the vegetation canopy was between 73 and 93 percent. Now the same area which once had poor vegetation cover before starting desertification control activities is under excellent class of vegetation cover. The area is free from wind erosion which was once under erosion. The tree species created favourable environment for the growth of other natural vegetation species and acted as windbreaks to protect the soil surface against strong winds. The area under trees plantation is completely stabilized and is beautifully green, botanical garden in the desert.

Afforestation of Various Trees Species for Stabilization of Sandy Areas

3.3 Rangeland Development

The overgrazed area devoid of vegetation was converted to good rangeland by fencing and prohibiting free livestock grazing as well as by introducing different species of trees, bushes, and grasses. The comparison of vegetation species with population of plants in the natural grazing land and controlled grazing land per 25 sq. meter is give in Table-4.

The number of species observed in the protected area were eleven and in the natural grazing area were 6 Nos. There were more species of palatable grasses and bushes in the developed area, while in the area free to natural grazing non-palatable species of vegetation were dominant.

Table-4: Vegetation Species of the Protected and Un-protected Areas

S.No	Name of Species	Controlled Grazing Area							Natural Grazing Area						
		Sites							Sites						
		1	2	3	4	5	6	7	1	2	3	4	5	6	7
		Nos. of Plants							Natural Grazing Area						
1	Cenchrus (Dhaman)	16	3	-	10	3	6	-	-	-	-	-	-	-	-
2	Sindicus (gorkha)	-	1	8	6	6	7	26	-	-	-	1	1	1	-
3	Eleusine (Chimber)	-	60	32	-	80	150	-	-	-	-	-	1	-	-
4	Cymbopogan (Khavi)	-	3	35	6	23	16	2	-	-	9	10	26	4	8
5	Calligonum (phog)	-	3	-	1	1	-	-	-	1	1	1	-	-	-
6	Haloxlon (lana)	-	-	-	-	-	5	18	-	-	-	-	-	-	-
7	Dipteregium (lathia)	1	1	-	1	-	-	-	1	-	12	22	6	2	-
8	Aerua jawanica (bui)	-	-	-	-	-	-	-	1	1	-	-	-	-	-
9	Mohabat Booti	-	-	-	-	-	-	10	-	-	-	-	-	-	-
10	Atriplex	1	1	-	-	-	-	-	-	-	-	-	-	-	-
11	Aristida depressa (lumb).	-	-	-	-	-	-	16	-	-	-	-	-	-	-
Total:		18	72	75	24	113	184	72	2	2	22	34	34	7	8

Source: PCRWR

Management of Rangeland

3.4 Grassland Development

Dry biomass of cultivated grasses under salinewater irrigation and natural grazing land at Dingarh with carrying capacity of each is given in Table-5.

Table-5: Biomass and Carrying Capacity of Grasses

Grasses Species	Dry Biomass (kg)	Carrying capacity per year*			
		Camel	Goat	Sheep	Cattle
Cenchrus ciliaris	15012	2	14	16	3
Panicum antidotale	12407	1	11	14	3
Lasurus sindicus	18274	2	17	20	4
Wild millet	38780	4	35	42	9
Natural grazing land	1141	-	1.25	1.25	-

(*) Dry Forage bio-mass requirement per animal per day sheep=2.5 kg; goat=2.5 kg; camel=25.0 kg; cattle =12.5 kg.

Natural grazing land produced 1141 kg dry biomass of palatable vegetation per hectare while cultivated grasses under saline water irrigation namely, Cenchrus ciliarus, panicum antidotale, lasiarus sindicus, wild millet (Napier bajra) produced dry palatable biomass of 15012 kg, 12407 kg, 18274 kg, 38780 kg per hectare respectively. The carrying capacity of natural grazing land per hectare is 1.25 sheep whereas fodder grasses cultivated under saline water irrigation had dry bio-mass 10 to 35 times more per hectare than natural grazing land. It indicated that if desert lands are properly seeded with the best grasses and irrigated even with saline water, the carrying capacity for livestock can be enhanced 10 to 35 times more than the natural grazing land of desert.

Grassland of Sindicus

Grassland of Panicum

3.5 Introduction of Orchard Plants

An orchard of date palm, grafted ber and local ber has been developed successfully at Dingarh in the Cholistan desert. The source of irrigation is rainwater collected in the reservoirs and groundwater being pumped by the tubewell. The quality of ground water is between moderately to highly saline. Therefore, irrigations to orchard plants are given in baby stage for one year with rainwater then after irrigations are applied alternatively with saline water and rainwater. The soils of the area are sandy and well drained.

3.6 Production of Crops with Saline Water

The Yield of barley and mustered crops irrigated with highly saline groundwater crops were lower than the yields of these crops with irrigation of good quality river water. The yield of crops per hectare of different blocks grown in the Cholistan desert is given in Table-6. The salinity environment around the plants root zone reduced their vegetative and root growth. As a result the plants remained stunted and produced less yield than under non saline condition. The yield falls under good to poor classes. The good and moderate yield of barley and mustard crops occurred where the soils were well drained, and level with adequate availability of moisture to seeds for germination and growth. Poor yields of barley and mustard occurred where soils were poorly drained and germination of seeds was less. To obtain good yield of crops under saline water irrigations it is essential to select rapid percolating soils and precision levelled fields to avoid adverse effects of salt in saline water on seed germination and subsequent growth. Yield of crops using saline water irrigations also depends on the salt tolerance of each crop, management practices, application of fertilizers, addition of manures and amendments as well as environment in which crop has been grown.

Table-6: Crops and Production

Block and Plot No.	Crop grown	No. of plants (m^2)	Height of plants (cm)	No. of tillers/ branches	No. of pods No. of grains per plant	Yield per/ha (Kg)
1	Barley	22	48	8	30	205
2	Barley	45	92	28	62	609
3	Barley	40	81	23	49	593
4	Barley	24	51	11	33	228
5	Barley	18	39	7	27	185
6	Barley	33	61	14	42	383
1	Mustard	11	70	10	125	124
2	Mustard	24	103	18	186	317
3	Mustard	5	60	6	80	111
4	Mustard	11	75	8	113	158
5	Mustard	30	135	25	295	418

Source: PCRWR

Barley Crop **Mustard Crop**

Conclusion

Integrated approach for management of water, soil and vegetation resources is an essential requirement for desertification control and sustainable use of desert lands.

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