

## POSSIBILITIES FOR RANGE DEVELOPMENT IN CHOLISTAN DESERT AS REFLECTED BY ITS PHYSIOGRAPHY AND SOILS

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**Abstract.** *For the purpose of range development, the Cholistan Desert has been divided, using aerial photographs and supported by adequate ground truthing, into a number of naturally occurring physiographic units which represent homogenous areas on the surface of land with respect to land attributes such as geology, landforms, soils, pedoclimate and vegetation. These units have been, on the basis of similar potential, grouped together into range management units having different capabilities and capacities for forage and livestock production and therefore requiring different management practices. Two maps, each showing the distribution and extent of physiographic units and range management units, have been prepared on a scale 1: 1,000,000.*

**Introduction.** Apparently the Cholistan Desert does not seem to have much worth for economic development. Detailed investigations in the area, however, yield tremendous amount of valuable information on possibilities of its development as rangelands. In this regard, studies were made on its physiography and soils as well as the associated vegetation.

The Cholistan Desert constitutes the southern part of Bahawalpur Division and lies between latitudes  $27^{\circ}42'$  and  $29^{\circ}45'$  north and longitudes  $69^{\circ}52'$  and  $73^{\circ}5'$  east., covering an area of about 27,800 sq.km. The area badly lacks in communication system. Camels and jeeps are the only means of transportation. Habitations are extremely scattered and small-sized. The economy of the area is in the main pastoral. Large herds of camels, cattle, sheep and goats graze in the area. Besides isolated flocks of Gazelle sp. (chinkara) also graze the area.

The climate of the area is arid, tropical and continental with a mean annual truly erratic rainfall of 100-200 mm; mean minimum of the coldest month  $-2.2^{\circ}$  C and maximum of the hottest month  $49.7^{\circ}$  C.

Most of Cholistan has underground water at depth of 30-40 metres, which except at spots here and there along the Indo-Pakistan border, is brackish, containing salts 9000-24000 ppm. (WASID). Apart from this, sweet water is also available at shallow depths, at many places.

Brackish water of 3000-4000 ppm. is known to be used for cultivation on sandy soils in the Middle East countries (National Academy of Sciences, 1974). The possibility of using brackish water for supplemental forage production in the area needs to be explored.

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It consists of a complex of two distinct terraces separated by a bluff ranging in height from about half a metre to three metres. The terraces are:-

- (1) Subrecent clayey terrace (10,000-1,000 years ago).
- (2) Dissected wind resorted sandy terrace of Hafizabad stage (17,000-10,000 years ago).

The Subrecent terrace is lower and comprises the saline alluvial flats making the Subrecent filled-in channels of the dying Harka river. The sediments of this terrace are predominantly clayey and the soils are invariably saline or saline-sodic. The vegetation cover which consists of xeromorphic halophytic plant species is true indicator of the saline soils of the region.

The wind resorted sandy terrace is higher and older than the former and is represented by patches of undulating to rolling sand ridges/dunes occurring as remnants of Pleistocene terraces. The sediments of this terrace are sandy which bear a vegetative cover consisting of true desert shrubs similar to those of the Greater Chojistan.

**Material and methods.** Photo-mosaics of the area at 1: 40,000 scale were studied and different patterns were separated out with the naked eye. These various patterns were then studied in detail with the help of a stereoscope using stereo-pairs with representative of each pattern and interpreted for soils occurring in each physiographic unit. During the interpretation, height, breadth, slope and orientation of the sand ridges and depressions were determined and the type of soils and associated vegetation occurring on different topographic positions in each of the interpreted units was guessed.

Ground checks were made along suitably selected traverses to verify the various physiographic units and their relationship with each other. Soils occurring on different topographic positions within each unit were studied and described according to the Soil Survey Manual (1951) and the FAO Guidelines for Soil Descriptions (1965). Opportunity was also seized to record species growing on each type of soil. The delineated units were transferred from the photographs on to the 1:50,000 scale topo-sheets which were ultimately reduced to 1:100,000 scale for convenience.

**Results.** In all seven physiographic units were recognized in the area. They are:-

- (i) high transverse sand ridges,
- (ii) low transverse sand ridges,
- (iii) alveolar and elliptical sand ridges,
- (iv) longitudinal sand ridges,
- (v) low barchan sand dunes,
- (vi) covered old channel remnants and
- (vii) saline alluvial flats.

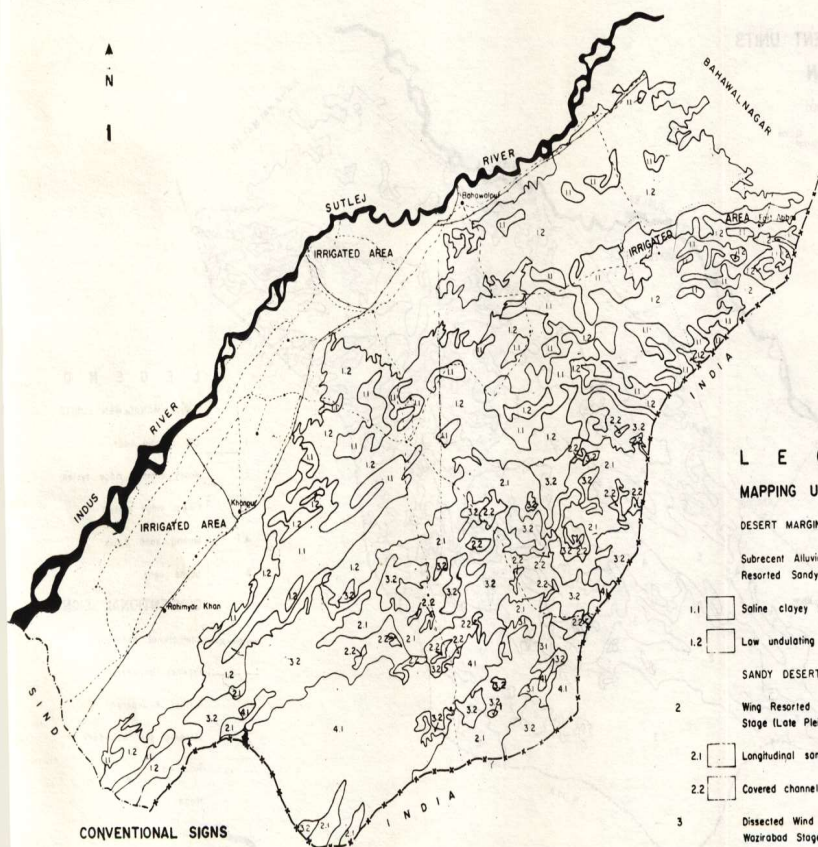


MAP — I  
PHYSIOGRAPHY  
OF  
CHOLISTAN

SCALE 1:1,000,000

0 20 40 Km

▲  
N  
I



CONVENTIONAL SIGNS

- X—X— International boundary
- — — Province boundary
- — — District boundary
- — — Mapping unit boundary
- — — Railroad
- — — Road
- — — River
- Town

LEGEND

MAPPING UNITS

DESERT MARGIN (LESSER CHOLISTAN)

Subrecent Alluvial Flats and old Dissected Wind  
Resorted Sandy Terrace

- 1.1 Saline clayey flats
- 1.2 Low undulating sand dunes

SANDY DESERT (GREATER CHOLISTAN)

- 2 Wing Resorted Sandy Terrace of Hafizabad  
Stage (Late Pleistocene, 17 000–10 000 years)
- 2.1 Longitudinal sand ridges
- 2.2 Covered channel remnants
- 3 Dissected Wind Resorted Sandy Terrace of  
Wazirabad Stage (Late Pleistocene, 50 000–20 000  
years)
- 3.1 Low transverse sand ridges
- 3.2 Alveolar and elliptical sand ridges
- 4 Dissected Wind Resorted Sandy Terrace of Islamganj  
Stage (Middle Pleistocene, 250 000–50 000 years)
- 4.1 High transverse sand ridges

They are shown in map-1.

Twenty five soil series were recognized in these physiographic units on the basis of differences in parent material, topographic position and degree and direction of soil development. Detailed account of model soil profiles of each soil series is given in Baig, et al, 1977.

Vegetation was recorded by listing species, occurring on various soils and varying with the physiography and soil.

**Range Management Units.** For convenience of evaluation for rangeland, seven physiographic units mentioned above were grouped into the following five range management units on the basis of similar potential for development. The distribution of these units have been shown on a map-2. The units are:-

Range Management Unit 1. Old channel beds.

Range Management Unit 2. Honey combed ridge system.

Range Management Unit 3. Linear ridge system.

Range Management Unit 4. Moving sand dunes.

Range Management Unit 5. Saline belts.

The physiography, soils, vegetation, main constraints and development/improvement possibilities of each management unit are given below:-

**Range Management Unit 1. (Old channel beds).** Patches of moderate sized old channel remnants occur throughout the sandy desert of Cholistan and occupy an overall area of 45000 ha.

These channels mark the drainage lines of the Late Pleistocene period filled with Late Pleistocene river alluvium. They were later covered by shifting of low sandy hummocks.

The predominant soils in this unit are sandy loams having moderate water-holding capacity. Small patches of loamy and clayey soils also occur locally. At places the soils are underlain by cemented lime (caliche) or gypsum accumulation zones which are the remnants of some very old terrace. This unit is generally level to nearly level, but locally some low undulating sand dunes or hummocks are also present.

Being old channel beds, they act as drainage ways of the area and collect most of the run-off. The soil moisture conditions in this area are therefore, relatively better than those of the surrounding landscapes. Due to the favourable conditions of recharge, the quality of the ground water is expected to be good, especially of the upper lenses.

The present vegetation includes a mixture of grasses, shrubs, and forbs. Among the grasses *Eleusine compressa* and *Cenchrus ciliaris*; among the shrubs, *Haloxylon salicornicum*



and among the forbs *Corchorus depressus* and *Euphorbia thymifolia* are important species. *Prosopis spicigera* grows around ponds (dug-in-tobas) and provides shade as well as supplemental forage for livestock. This unit attracts a large number of cattle and sheep due to its favourable relief providing them easy accessibility and movement, relatively better cover of grasses and forbs, relatively better availability of drinking water and shelter and protection. The unit is therefore, subject to continuous overgrazing, the pressure of grazing being manifold than its grazing capacity. Due to the combined effect of overgrazing and aridity, the vegetation cover is very sparse. Currently this unit is producing far below its potential production level. Stock watering points are few and far between and the livestock has to travel long distances for water.

This unit has a high potential for development as cattle and sheep range. Improvements in forage production could be made by reseeding of grasses like *Cenchrus ciliaris* and *Lasiurus hirsutus*, and growing annual legumes such as *Medicago hispida*, planting forage trees like *Ziziphus jujuba* around watering points (tobas) and adopting planned rotational grazing. Further increase in forage/fodder production could be achieved by cultivating patches of the unit where both soil and ground water resources allow, for supplementary fodder. More watering points could be developed by installing small-size transportable tube-wells at suitable places. Possibilities for installing wind mills are to be explored.

**Range Management Unit 2.** (Honeycombed ridge system). This unit occurs in patches in the central part of the survey area in the wind resorted sandy terrace of Wazirabad stage in a transitional belt between the transverse and longitudinal sand ridge systems and occupy an area of 395,000 ha. They appear to be a composite of the aforementioned types of sand ridges. The transverse ridges are older and belong to Wazirabad stage, whereas the longitudinal ridges are younger and belong to Hafizabad stage. Their existence together appears like marriage between the two, a fact which is explained by the relative degree of development of soils on the two ridges. The NW-SE orientation of the transverse ridges is maintained in the alveolar ridges but they are joined by cross ridges oriented NE-SW, thus forming a honeycombed system.

This system contains 65 per cent rolling sand ridges, 35 per cent enclosed level to nearly level interr ridge depressions. The windward faces of the ridges have stabilized sands whereas the slip faces of the ridges have shifting sands. The depressions contain loamy sands towards the base of the windward faces of sand ridges and sandy loams in the lowest parts. Loamy sand soils are excessively drained and have a low water-holding capacity. Sandy loam soils occupying run-on positions, have moderate water-holding capacity.

The soils on the transverse ridges are weakly developed fine sands containing few fine scattered lime nodules on the windward faces whereas the soils on the cross ridges are slightly less developed than those of the former, although the texture is the same. The inter-ridge depressions are enclosed and contain weakly developed sandy loam and loam soils. The crusts and the slip faces of all the ridges invariably contain slightly developed and loose fine sands respectively.



The sandy soils of this unit with rolling relief form are subject to severe arid conditions. On the other hand sandy loam soils of depressions which receive additional run-off water by nearly as much as one-third of the precipitation falling on the sand ridges receive nearly double the mean annual rainfall of the area.

The natural vegetation growing on various physiographic positions in this unit consists of *Calligonum polygonoides*, *Tribulus terrestris* on sandy ridges; *Eleusine compressa*, *Haloxylon salicornicum*, some dried stubbles of *Cenchrus ciliaris*, *Lasiurus hirsutus* and some forbs like *Corchorus depressus* and *Euphorbia thymifolia* grow in depressions.

As against the soils on the unfavourable relief of this unit, the soils of depressions have a potential for increased forage production by reseedling of grasses such as *Cenchrus ciliaris* and *Lasiurus hirsutus* as was practised on similar areas in India (FAO/UNESCO, 1973) with a rainfall of 125-200 mm. Small doses of slowly soluble phosphate fertilizer may be tried to stimulate early growth. Plantation of cuttings of *Calligonum polygonoides* and *Tamarix articulata* on sand ridges may also be helpful to increase forage production as well as sand stabilization.

**Range Management Unit 3.** (Linear sand ridge system). This unit is composed of transverse and longitudinal sand ridge systems covering an area of about (790,000 ha.) The transverse sand ridges consist of two types depending upon their height and breadth. Accordingly they are termed as high or low transverse sand ridges. The high transverse sand ridges belong to the Middle Pleistocene period and are as high as 100 metre and as wide as one and a half kilometer. Low transverse sand ridges pertain to Late Pleistocene period and are as high as 3-5 metres and as wide as 60-90 metres. Both these types of transverse sand ridges lie perpendicular to the SW-NE wind direction which was responsible in their formation in the past, being aligned in the NW-SE direction. The ridges and inter-ridge depressions respectively occupy about 70 percent and 30 percent of the area (350,000 ha) under this ridge formation. The windward slopes of the ridges are gentle (4-8 percent) whereas the leeward faces are very steep (150-180 percent). The longitudinal ridges belong to the Late Pleistocene period. They lie parallel to the predominant winds which blow from SW in summer. Accordingly, the ridges are aligned SE-NE direction. The ridges are 3-5 metres high, 30-45 metres wide with gentle slope (2-6 percent) on the windward side and steep slope (about 100 percent) on the leeward faces. The ridges and inter-ridge depressions respectively occupy 60 percent and 40 percent of the area (440,000 ha) under this ridge system respectively. They occur as an unconnected system of irregular ridges. The ridges gradually decrease in height and size away from the SW wardly winds. This is probably due to the gradual decrease in wind velocity and/or supply of sand in the Late Pleistocene period. While the high transverse sand ridges have formed in sandy material mainly from Arabian Sea and the Rann of Cutch, the low transverse and longitudinal sand ridges have developed mainly from the river alluvium.

The soils on stabilized windward faces of all the sand ridges are brown, deeply homogenized, moderately calcareous fine sands containing very few to common fine to medium lime nodules in the soil and on the surface. The crests and leeward faces contain moderately calcareous, semi-stabilized and shifting sands respectively with greyish colour and



without lime nodules. The depressions have loamy sand soils near the base of the windward faces but sandy loam and loam soils on the lower parts of the depressions. The soils are brown/dark brown in colour and are deeply homogenized with weak coarse subangular blocky structure in the subsoil. The loamy sand soils are excessively drained and have low water-holding capacity, whereas the sandy loam and loam soils are well drained and have good water-holding capacity. The depressions being open, the run-off gets drained and consequently, the area is extremely dry.

The vegetation is very scanty, and comprises shrubs, grasses and forbs of low nutrition value. The dominant species are *Calligonum polygonoides*, *Dipterygium glaucum*, *Haloxylon salicornicum*, *Tribulus terrestris* and, *Eleusine compressa*. Next in importance are *Cymbopogon jawarancusa*, *Leptadenia pyrotechnica*, *Aerua jawanica* and *Aristida depressa*. *Calligonum polygonoides* is confined to sand ridges, whereas *Haloxylon salicornicum* is found in the depressions. Other species grow indiscriminately on both the ridges and depressions. Some forbs like *Corchorus depressus* and some grasses like *Lasiurus hirsutus* are also found both in the depressions and on the stabilized ridges. Some trees of *Prosopis spicigera* and *Capparis decidua* also grow in the depressions. Locally *Prosopis spicigera* is also seen on the leeward faces of some ridges, indicating that the ridges have moved to cover part of the area in the depressions which is the proper habitat of *Prosopis spicigera*.

Present condition of the range is deteriorated due to the combined effect of extreme overgrazing and aridity. More palatable species have been replaced by less palatable plants. For want of proper forage, even these unpalatable species are browsed of necessity by the livestock, only camels and goats, resulting in further thinning out of the vegetation.

The forage production from this unit could however, be increased by adopting modern range management practices including particularly planned rotational grazing and development of watering points at suitable distances to allow regrowth of vegetation and uniform grazing. Planting of cuttings of *Calligonum polygonoides* and *Tamarix articulater* may help increasing the forage production as well as in fixing the shifting sands. Reseeding of native grasses like *Cenchrus ciliaris* and *Lasiurus hirsutus* with small application of phosphate fertilizer may be tried on run-on sites in the depressions.

**Range Management Unit 4.** (Moving sand dunes). This unit occurs in patches in the desert margin (Lesser Cholistan) and covers about 1080,000 ha. It includes mainly undulating to rolling sand dunes and narrow inter-dunal depressions. The dunes are mostly of shifting nature and are advancing northwards. The dunes and depressions contain sands and loamy sands respectively. Locally minor patches of sandy loam soils are also encountered in some depressions. The soils being excessively drained and with low water-holding capacity, suffer from extreme physiological drought.

The unit occurs in the proximity of the settled irrigated areas and therefore, has suffered the most from the pressure of grazing and unauthorized cutting. Due to extensive and indiscriminate removal of the green cover of the area, most of the dunes have been reactivated and they are moving to cover depressional soils as well as the adjacent irrigated



agricultural lands. The present vegetation cover which is very sparse comprises mainly *Calligonum polygonoides* and *Haloxylon salicornicum* species which are of low nutritional value and palatable to only camels and goats. Plant species of high forage value have completely vanished due to the continuous overuse of this unit. Determined efforts to re-establish the vegetation cover by biological means to stabilize the moving sand dunes, which are a threat to the adjacent agricultural lands, are urgently needed in this area. This would include plantation of suitable species such as *Calligonum polygonoides* and *Tamarix articulata* on the dunes coupled with complete closure of the area to grazing. Reseeding of grasses in this unit does not seem feasible, due to the danger of burial of grass seedlings by moving sands as well as the lack of sizeable patches of good depressional soils.

**Range Management Unit 5.** (Saline alluvial belts). This unit occurs in desert margin (Lesser Cholistan) and comprises saline alluvial flats making the Subrecent filled-in channels of Hakra river and covering an area of about 470,000 ha. The soils in the alluvial flats are predominantly brown/dark brown clays and silty clays which are homogenized to moderate depths and have a weak coarse subangular blocky structure in the subsoil. They are moderately calcareous and severely saline or saline-sodic.

The soils occurring in the saline alluvial belts are mainly barren. Locally, however, a sparse cover of xeromorphic halophytic plant species like *Haloxylon reourvum*, *Sueda frutescens*, *Salsola foetida* and *Tamarix gallica* are found. These species are of low palatability and nutritive value providing browse mainly to camels. Goats and sheep also occasionally browse particularly in years of drought when no other forage is available or at times when they have to fulfil their salt requirements. The unit has been under intensive grazing and due to this continuous overuse is now at its lowest level of production. Forage production could however, be improved by applying modern range improvement and management techniques but development of this unit for range would not be economic.

If ample assured water supplies are made available all the year round, the saline soils containing gypsum could be reclaimed by mere leaching. After reclamation these soils could be brought under cultivation of all the common crops suited to the climate of the area. If such a scheme is undertaken then a substantial part of the reclaimed land must be integrated with the grazing areas to provide fodder to the livestock of the area. Before these lands are reclaimed for cultivation, stabilization of the nearby sand dunes is a must, which could be achieved by planting cuttings of *Calligonum polygonoides* and *Tamarix articulata*, otherwise the moving sand dunes would remain a hazard and bury the reclaimed lands.

**Discussions and Results.** From the foregoing, it has been established that topographic form is the main factor playing a vital role towards the development of Cholistan desert as a rangeland. Various relief positions control the occurrence of soils, and availability of moisture for the vegetative growth. For example in the southern region (Greater Cholistan), ridges invariably contain sands which have very low water-holding capacity while the inter-ridge depressions or old channel beds contain loamy sands, sandy loams, or loams which have good water-holding capacity. The type of depressions also plays an



important part in rangeland development under such environment. The Unit No. 1, which consists of patches of old channel beds and act as drainage ways of the area collects most of the run-off of the area. Soils of such channel beds are mostly sandy loams having moderate water-holding capacity. Thus the availability of moisture in these channels is more and capable of supporting annual grasses and legumes as a supplementary fodder. Again due to its favourable relief and availability of drinking water points, this unit is more suitable for cattle raising.

In the honeycombed ridge system (Unit No. 2), the inter-ridge depressions are enclosed. These depressions receive additional run-off from the adjacent ridges and effective precipitation in them is nearly double the mean annual rainfall of the area. Thus these depressions, with favourable soils, have quite a good promise to grow palatable species of vegetation. The unfavourable relief would however, restrict the movement of cattle but would have no hinderance for the camels and goats. This unit comes next in priority for development as rangeland.

In the linear ridge system (Unit 3), the ridges and depressions on an average cover 65 per cent and 35 per cent of the area respectively. Here the depressions are open, consequently the run-off water gets drained and area under this unit suffers from extreme aridity. The windward faces of sand ridges in all these three units are stabilized and support vegetation. This unit would however, get lower priority in the development possibilities.

In the northern regions (Lesser Cholistan), due to the presence of moving sand dunes and absence of well marked depressional areas (Unit 4), and presence of saline alluvial belts (Unit 5), the prospects of range development are not as bright as the case of southern region (Greater Cholistan). Again these areas are located adjacent to the settled irrigated areas and, therefore, suffer most from the pressure of grazing and unauthorized cuttings. Stabilization of sand dunes through re-establishment of vegetation and complete closure of the area to grazing and cutting would improve the lot of the area under unit 4, which would, however, always remain only poor rangeland.

The development of Unit 5, consisting of saline alluvial flats have the lowest priority in development possibilities and its improvement as rangeland would be uneconomic.

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