SOCIO-ECONOMIC DIMENSIONS AND ECOLOGICAL DESTRUCTION IN CHOLISTAN

By

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Thesis submitted to the Department of Geography, University of Karachi for partial fulfillment of the requirements for the Degree of Doctor of Philosophy

DEPARTMENT OF GEOGRAPHY UNIVERSITY OF KARACHI KARACHI - PAKISTAN 2001
DEDICATED TO

MY RESPECTED MENTOR

Dr. Iqtidar H. Zaidi, Professor (Late)
who planted the seed of learning in my mind.
ACKNOWLEDGEMENTS

I feel greatly honoured and privileged to study socio-economic dimensions of desertification, possibilities for range development, runoff collection and rehabilitation strategies in Cholistan desert under co-supervision of Dr. Iqtidar H. Zaidi, Professor (Late) and Dr. Syed Jamil Hasan Kazmi, who nourished my brain during the study. I am fortunate enough to be a pupil of great scholars. Their guidance has transported me to the new horizons of knowledge.

I express my sincere thanks to Mrs. Birjies Talal, Chairperson, Department of Geography, University of Karachi for their constant help and encouragement.

The help and guidance of Dr. Farhat Gulzar, Chairperson, Department of Geography, University of Punjab, Dr. Amir Ahmed Khan, Chairman, Department of Geography, University of Peshawar and Dr. Mohammad Khan Malik, Chairman, Department of Geography, Islamia University Bahawalpur is acknowledged with thanks.

I am grateful to Leonid Kroumkaichev, Technical Advisor, United Nations Environment Programme (UNEP), Barbara Hutchison, Arid Lands Information Center, The University of Arizona, USA, Prof. Dr. German S. Kusli, Institute of Soil Science, Moscow State University, Moscow, Nikolai Kharin, Center on Problems of Ecology and Productivity of Forests, Russian Academy of Sciences, Moscow, Bruce Alchin, The University of Queensland, Dr. Warren Bond, CSIRO, Dr. David Eldridge, Centre for Natural Resources, University of New South Wales, Australia, Dr. M. Aslam Khan, UN-ESCAP, Thailand, James A. Young, Range Scientist, USDA, Sylvie Bovernier-Meinert, UNRISD, Alsan Tayyab, Asian Development Bank, Dr. Mary Seely, The Desert Research Foundation of Namibia, Stephanie R. Horowitz, Institute for Development Anthropology (IDA), Binghamton, New York, International Fund for Agricultural Development (IFAD), Food and Agriculture Organization (FAO) for providing me valuable research material and books for completion of my thesis.

I am also grateful to Prof. Dr. Allaf-Ur-Rehman Rao, and Dr. Mohammad Arshad, Cholistan Institute of Desert Studies, Islamia University Bahawalpur, Chaudhry Mohammad Akram and Dr. Mohammad Abdullah, Pakistan Council of Research in Water Resources (PCRWR), Zaheer Ali, Executive Engineer, Cholistan Development Authority (CDA), Dr. Ghulam Akbar Mughal, Rangeland Research Institute, NARC, Dr. Zahid Hussain, Pakistan Agricultural Research Council (PARC), Mohammad Ajmal Khan, Arid Zone Research Institute (AZRI), Mohammad Anwar Butt, Jojoba Research Station, Bahawalpur, Muhammad Shabbir Baig, Soil Survey of Pakistan, Dr. Abdul Wahid Jasra, National Aridland Development & Research Institute (NADRI), Dr. M. Tahir Qureshi, IUCN-The World Conservation Union and Tanveer Arif,
Society for Conservation and Protection of Environment (SCOPE) for supplying me maps and data.

While concluding, I would like to express my thanks to Dr. Fazle Karim Khan, Prof. Abdur Rauf Khan, Dr. Mohammad Said, Prof. Israr-ud-Din, Dr. Ahsan Ullah, Prof. Dr. Masaud Aslam Mian, Miss Tasneem Kausar, Dr. Usman Ali, Prof. Mehboob Yazdani, Prof. Abdul Aziz Baloch and Mudassar Hassan Arslan.

I am thankful to my parents, who helped me in my academic career with their limited financial resources and thankful to my sisters: Miss. Huma Jabeen, Miss. Farkhanda Jabeen and my younger brothers: Moeen-ud-Din, Shoab Abdullah for their co-operation in the completion of my thesis.

I offer my expression of gratitude to those whose names do not come readily to mind as I write this. If through carelessness, I have forgotten any of those who have helped me, it is my loss, and so I offer thanks to you now. Finally, continuing a tradition essential in writing acknowledgements, I claim full responsibility for any error of presentation or interpretation which clearer heads may find here, this effort is largely my own, and its faults are exclusively so.

Last but not least this study would never have been possible without paying gratefulness to Dr. Iqtidar H. Zaidi, Professor (Late) and Anis Ahmad Abbasi Professor (Late), who planted the seed of learning in my mind. It is their affection and teachings which boost my inspiration to complete this uphill task.

FAROOQ AHMAD
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SUMMARY

Thesis Proposal for Ph.D.

SOCIOECONOMIC DIMENSIONS AND ECOLOGICAL DESTRUCTION IN CHOLISTAN

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The proposed study sought to identify socioeconomic mechanisms used traditionally by indigenous communities to manage their natural resources; to highlight contemporary forces leading to land degradation, agricultural encroachment on rangelands, fluctuations in vegetation biomass in Cholistan which is influenced primarily by the seasonality of rainfalls, periodic droughts and social discord. UN Convention to Combat Desertification takes a firm stand on the significance of incorporating the local system of resource use into the national level planning and implementation of development action. The proposed research work thus comes under the purview of the UN Convention to Combat Desertification. The efforts to improve the Cholistan desert environment should focus on limiting agricultural expansion while assisting herders to enhance their economic and social status by facilitating access to affordable sources of grazing and to marketing avenues that would improve nomads' terms of trade with urban consumers in form of pastoral produce. The approach must be regional, but the interventions must take into account specific ecological and human activities. In this study, the objectives are threefold: 1) to point out the main causes of desertification in Cholistan; 2) Vegetation biomass in Cholistan; and 3) Rain water harvesting to combat the desertification process in Cholistan. These objectives will be achieved by studying the perception of local people through questionnaire for which random samples will be drawn from selected areas. The record of various governmental departments, like Pakistan Council of Research in Water Resources, Cholistan Development Authority, Cholistan Institute of Desert Studies, Arid Zone Research Station and Pakistan Agricultural Research Council, will be examined. The data will be supplemented by the satellite imageries, which is the most credible and modern source of information in today's geography. From all these sources, I will collect essential data alongwith desirable maps to achieve the objectives of this research.
تقریر

اس تحقیق میں ہمارا لحاظ مکملگہ کے روایت سانیاتی و معاشرتی طریقۂ کار خصوصیً متعلق لوگ قدرتی رسالہ کور ور کر کا
لا ہے - اور ایسے روایت سانیاتی و معاشرتی طریقۂ کار نے اضافی نیاتی اور نبودجہی نسکی اور فتحیہ مقدس میں سے متعلق لوگ قدرتی رسالہ کور ور کر

سامل کا سامنا ہوا اس وقت کہ ہماری گفتگو بانی تاریخی اور مشہور کاسحرا کارکی کی رول کو خصوصی پر اعمال اور بات کی نتیجہ نویس

چکھتے ہیں۔ معاشرتی میں اسی طرح کے نظریاتی جنگوں کے موضوعات کے ساتھ، ہمارا کارکی قبّہ پر انسانی قابلیتیا یہ

یہ تحقیق مکمل ہے میں کہ خوشش جو ہم نے گیا ہے کہ ہمارے کردار کی دلیل میں سے جو ہمارا کارکی کی رول کو خصوصی پر اعمال اور بات کی نتیجہ نویس

ہمارے تحقیقی اجتہاد کی جو انسانی کاگول و کی کورنوول کے انسانی کی سائنس و معاشرت میں اضافہ کی ہو کے

یہ تحقیق مکمل ہے لک کہ خوشش جو ہم نے گیا ہے کہ ہمارے کردار کی دلیل میں سے جو ہمارا کارکی کی رول کو خصوصی پر اعمال اور بات کی نتیجہ نویس

(1) پاکستان میں ضرور کارکی کی دلیل میں اضافہ

(2) پاکستان میں بات کی نتیجہ نویس

(3) انسانی کاگول و کی کورنوول کے انسانی کی سائنس و معاشرت میں اضافہ کی ہو کے

یہ تحقیق مکمل ہے لک کہ خوشش جو ہم نے گیا ہے کہ ہمارے کردار کی دلیل میں سے جو ہمارا کارکی کی رول کو خصوصی پر اعمال اور بات کی نتیجہ نویس

پیمہ وسیع پاکستان میں مختلف طرق میں لوگوں کی آپ اور خود کے حصول کی بنیاد کے تجربے گیا۔ اس کا اہمیت

کی چاہے کہ مختلف کامیابی اور روشنی پاکستان کے متعلق لوگ قدرتی رسالہ کور ور کر کے

تحقیق پاکستان و اس کے متعلق لوگ قدرتی رسالہ کور ور کر کے متعلق لوگ قدرتی رسالہ کور ور کر کے

مقاوم جو ہمارے کردار کے متعلق لوگ قدرتی رسالہ کور ور کر کے متعلق لوگ قدرتی رسالہ کور ور کر کے

حاصل شدہ تحقیق میں لوگ قدرتی رسالہ کور ور کر کے متعلق لوگ قدرتی رسالہ کور ور کر کے

معلومات عامل کر نے کا بہت بڑا ہو گی۔
CHAPTER 1

INTRODUCTION

Cholistan is an extension of the Great Indian Desert, which includes the Thar Desert in Sindh province of Pakistan and the Rajasthan Desert in India (Figure 1), covering an area of 26,330 Km². It lies with in the southeast quadrant of Punjab province between 27°42’ and 29°45’ north latitude and 69°52’ and 73°05’ east longitude (FAO/ADB, 1993; Arshad et al., 1995; Jowkar et al., 1996 and Ahmad, 1999b). The word ‘Cholistan’ has been derived from a Turkish word, ‘Chol’, which means a desert, while some historians believe that this name has been distorted from Iraqi (Kurdish) word, ‘Chilistan’ meaning ‘waterless waste land (Ahmad et al., 1992; Auj, 1995 and Ahmad, 1998a, 1999b), popularly Cholistan is known as ‘Rohi’. In a dialect still spoken in some parts of Tibet, ‘roh’ means a hill, from which the name Rohilla has been attributed. In fact, Rohi has been derived from the Pushto word ‘roh’, meaning is a sandy desert. The man from Rohi is called Rohilla (Auj, 1987a, 1991). However, a reference has been made in Geography of Sindh, that the word Cholistan has been derived from the ‘Seraiki’ word ‘Wacholo’, meaning ‘in between’. Since this desert is situated between the Thar and Rajasthan deserts, it was called ‘Wacholo’, which later became ‘Cholo’ and then Cholistan. This appears to be a more probable explanation for the origin of this word (Khan, 1992).

1.1 The Problem

Pakistan is a tropical country with vast semi-arid and arid tracks of land spread over 68 million hectares with the population of 130.580 million people in 1998 as against 84.254 million in 1981 showing an average growth rate of 2.61 percent
(Government of Pakistan, 1998). All of its provinces possess large share of land with valuable natural resources, which are being degraded at very high rate i.e., Punjab 119,310 Km², Sindh 134,896 Km², Baluchistan 149,467 Km² (Arshad and Rao, 1994b; Alamud, 1997c; 1997d; 1998c; 1998e; 1999a) and its proportion is increasing because of over-exploitation of under-developed meadows beyond quick rehabilitation.

The economy is predominantly agricultural based, fertile soil and water resources both are reaching the limits of low cost opportunities simultaneously. Some areas are less productive due to deficiency of water while others have the problem of excess water in the form of heavy rains during a part of the year and too little during the rest of the year.

The productivity of agricultural crops in Pakistan is becoming low and low year by year as shown in table 1. Summer cropping is of limited extent because of high evapotranspiration and damage of sandblasts. Gram, mustard, barley and wheat is grown using summer moisture while dry farming is marginal with 160 to 200 mm rainfall. Well-irrigated agriculture is practiced over small areas.

### Table 1

<table>
<thead>
<tr>
<th>Crops</th>
<th>Actual yield level yield Kg/ha</th>
<th>Recommended level, Kg/ha</th>
<th>Unachieved potential, %</th>
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<tbody>
<tr>
<td>Wheat (irrigated)</td>
<td>2717.5</td>
<td>3013.5</td>
<td>44.0</td>
</tr>
<tr>
<td>Rice (irrigated)</td>
<td>2239.0</td>
<td>3320.6</td>
<td>40.7</td>
</tr>
<tr>
<td>Rice (irrigated)</td>
<td>418.2</td>
<td>564.2</td>
<td>35.8</td>
</tr>
<tr>
<td>Groundnut</td>
<td>1055.5</td>
<td>536.5</td>
<td>56.2</td>
</tr>
<tr>
<td>Millet</td>
<td>2125.0</td>
<td>3054.0</td>
<td>36.7</td>
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Grazing is practiced in comparatively small areas, rangelands have a high animal pressure, which is higher than the carrying capacity of the land. Livestock raising
is not so important in the national economy. Most animals are used for draught purposes. In arid regions there is nomadic herding of sheep and camels.

The government is indeed, striving hard for the development of the country but this development will be meaningless, unless we first resolve the basic and fundamental problems caused due to environmental degradation which threaten the survival of the growing population of the country.

1.2 Scope and objectives

In this study, the main causes of desertification would be explored to discover the impacts and changes in the geographical set up of aridlands and how it is going to change the socio-economic conditions of the people.

Pakistan is an agrarian country and the agriculture is the backbone of its economy. If deterioration in agricultural sector is allowed to continue, our goal to achieve self-reliance in food grains would become more and more difficult. Unemployment, poverty and rural-urban migration will increase in the country. Therefore, it is high time to conduct some serious and thought provoking studies on desertification.

Being an agrarian country its industry also depends upon agricultural raw material. Now when we are competing in international markets with our recognized agricultural commodities in this age of information technology, desertification would certainly become a threatening hazard for the economy of Pakistan. The efforts to improve the Cholistan desert have focus on limiting agricultural expansion while assisting herders to enhance their economic and social status by facilitating access to affordable sources of grazing and to marketing avenues that would improve nomads’ terms of trade with urban consumers in the form of pastoral production.
The underlying hypothesis of this study is to explore how socio-economic conditions have contributed in the process of desertification in Cholistan. On the contrary, author would like to investigate how cultural indigenous methods would be helpful in combating desertification and I sought to achieve the following objectives:

1) To conduct an in-depth spatial analysis on the following socio-economic dimensions of desertification in Cholistan;
   - Social hierarchy
   - Transhumant
   - Local perception
   - Nomadic system
   - Nomadic-sedentary conflict
   - Gender division of labour and poverty
   - Natural grazing
   - Traditional grazing system
   - Carrying capacity
   - Water demands of livestock species
   - Water frequency
   - Actual drinking water requirement
   - Domestic water use
   - Public health
   - Quality of life

2) To investigate vegetation biomass in Cholistan;
   - Plant genetic resources
To explore the possibility for development of under-utilized industrial and medicinal plants,
- Fibre plants
- Oilseed (non-edible)
- Gums
- Herbal plants
- Miscellaneous plants

To seek the opportunity of native plants as a source of food during famine,
- Wild fruits and seeds
- Leafy material and roots
- Khip – silver fibre of Cholistan desert
- Jojoba – an economic oilseed plant

3) To explore the indigenous rainwater harvesting techniques to combat desertification process in Cholistan;
- Topographical form and runoff collection
- Surface water development for irrigation
- Ecological restoration
- Strategic interventions

4) To review the course of historical development that has change the geographical settings of the environmental conditions;
- Cholistan: Cradle of Hakra Valley civilization
- Archaic views about Hakra depression.

It has been conceived that topographic form is the main factor playing a vital role towards the development of Cholistan desert as rangelands. Various relief positions control the occurrence of soils and availability of moisture for the vegetation growth. For example, in southern region (Greater Cholistan), ridges invariably contain sands, which have very low water holding capacity while the inter-ridge depression, or old channel beds contain loamy sand, sandy loam or loam which
have good water holding capacity. The type of depression also plays an important role in rangeland development. The old takra bed acts as drainage ways of the area and collects most of the runoff. Soil of such channel bed is mostly sandy loam having moderate water holding capacity. Thus, the availability of moisture in the channel is more and capable of supporting grasses and legumes as a supplementary fodder. For the overall development of the desert, existing plant resources must be exploited on sound scientific lines.

In Cholistan, the catchment area lies adjacent to the fields on same level, it is known as micro-catchment system. The runoff water flows only a short distance. Micro-catchment systems are effective for use in growing trees, shrubs, collecting rainwater and precipitation (Pacey and Cullis, 1986).

Water harvesting/runoff-farming techniques are technically sound methods of water supply. There have been many water-harvesting/runoff-farming systems constructed and evaluated at many different places in the world. Some of the systems have been outstanding successes, while others were complete failures. Some of the systems failed, despite extensive effort, because of material, and/or design deficiencies. Other systems failed, despite proper material and design, because of social and economic factors that were not adequately integrated into the systems (Frasier, 1983; FAO, 1994). These systems failed because of personnel changes, water was not needed, lack of maintenance, and/or because of communication failures. A successful system must be:

- Technically sound, properly designed and maintained,
- Socially acceptable to the water user, and
- Economically feasible in both initial cost and maintenance at the user level.
1.3 Significance of the study

A study of the spatial aspects of desertification and its indicators is a unique contribution to the field of Geography. This study falls within the jurisdiction of environmental geography and desert ecology which has not yet attracted the attention of Pakistani geographers. Presumably, a study based on Cholistan desert may not be equally valid in other deserts as well. Nevertheless, it does attempt to develop a conceptual framework within which certain hypothesis about desertification and its indicators may be tested from which surrogate generalizations may be formulated. Because desertification is a worldwide hazard especially for sub-tropical countries, it is possible that the findings of this study might be replicatory in other countries, with more or less same environmental conditions.

Range Management units (figure 28), Land System map (figure 29) and Potential rainwater harvesting sites of Cholistan (figure 20 b) are entirely new contribution, unavailable in any published work. These maps have been carefully compiled from the integration of information on climate, geomorphology, soil, wind erosion and vegetation (Mega Land Systems have been split into eight Macro Land Systems based on geomorphology as it controls soils, moisture and eventually vegetation – an important component of range ecosystem, upon which pastoralism depend). Field survey was conducted with the collaboration of Soil Survey of Pakistan for micro classification of the soil and Cholistan Institute of Desert Studies for identification of indigenous plant resources. 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 Profile Descriptions (1965). The units delineated on the map are bio-physically homogeneous, versatile
and can be used confidently for land use planning of crops, range/livestock, irrigation and road alignment.

There exists a general dearth of such studies in the context of Pakistan. Hence, the study is expected to create a better awareness about the menace of desertification and of the way a geographical approach can be meaningful to control desertification in Pakistan. All physical, social, economic and environmental conditions have been brought under observation.

1.4 Approach and methods

In this study, the Rapid Rural Appraisal Survey instrument is used to gather information on Cholistani families. A village survey instrument was employed in-group interviews and farmer survey instrument was employed to record discussions with individuals. Survey was conducted in three Tehsils, Yazman, Liaquat Pur and Fort Abbas, one in each three Districts, Rahimyar Khan, Bahawalpur and Bahawalnagar respectively of Bahawalpur Division. Five communities were selected in each District and 30 families were interviewed in each community.

The cultural model in Cholistan assumes that men are the economic providers whose role is variable and dynamic, while the women are domestic consumers whose role is essentially static. Finding suggests that women's economic behaviour in Cholistan is not as dependent as often assumed and that, given the widespread poverty in the area, their behaviour is almost uniform. Women make vital economic contributions not only for their own support but also for the support of their family.

Livestock are major component of the population system in Cholistan. Herds of migratory cattle, camel, goats and sheep travel between summer and winter grazing
lands in search of water and forage. Settled farmers also raise livestock, especially small ruminants, stall-fed cattle and buffaloes.

There are two dominant production systems in the surveyed communities: i) the agro-pastoral system representing about 75% of the population, composed of irrigated agriculture undertaken in association with the raising of livestock that are either stall-fed or grazed in the desert; and ii) a pastoral system which comprises chiefly of a transhumant element, involving the seasonal movement of people and livestock in the desert made up of herders tending goats and camels permanently located in the desert together representing about 25% of the population.

There are three major constraints in conducting this survey, time, resources and accessibility to the communities. Many of the communities selected were within a three kilometer radius of a metalled or a hard surface road. Many were isolated and difficult because of poor or no roads. Survey was conducted in some communities after walking several kilometers. Other methods alongwith the Rapid Rural Appraisal Survey have been used to monitor desertification in Cholistan are:

- Physical evidences,
- Historical evaluation,
- Statistical analysis,
- Cartographic techniques.

1.5 Sources and quality of data

How good is the data? An answer to this question will reveal the quality of research on a given situation as well as the importance that is concerned to that situation in the society (Kazmi, 1997a). The nature and characteristics of the situation is also the level of sophistication of the information available reflects the
significance that is being involved to ecological degradation by the Government and people of Cholistan.

There can be several criteria for judging the value of set of data. Each researcher selects some of them in accordance with the requirements of the objective and disciplinary matrix of the chosen research proposal.

From the geographic point of view the most important question that can be raised here is whether the data is collected on sufficiently detailed spatial scale so that a study on the higher scale of the spatial hierarchy is made possible. Second main criteria on the basis of which one can judge the quality of data is the method that is used in collecting and tabulating the data. The third important measure of the quality of data can be the credibility of the source; viz., the individual or government or private organization that is involved in the collection of data (Kazmi, 1997a).

The data used in this study has been derived from the relevant published and unpublished reports of Pakistan Council of Research in Water Resources (PCRWR) and Pakistan Desertification Monitoring Unit (PADMU). Furthermore, data has been collected for some desert ecological indicators that are associated with desertification, broadly include socio-economic and cultural indicators. Data for all these measures have been derived from Cholistan Development Authority (1996), District Census Report (1981) and Population and Housing Census of Pakistan (1998).

As regards the agencies that were involved in ecological rehabilitation of Cholistan, author accepts their credibility that was done by Pakistan Agricultural Research Council (PARC) under the Ministry of Food and Agriculture, Government of Pakistan under the guidance of FAO, UN-ESCAP and UNEP.
In addition to that and to check the reliability and credibility of the above data, some useful data has been collected from Soil Survey of Pakistan and Cholistan Institute of Desert Studies, Islamia University Bahawalpur.

Land System terminology applied in this study is synonymous to that of the agro-ecological zone, presented in National Conservation Strategy (Government of Pakistan and IUCN, 1992), which is commonly used at a small (National) level. The use of Land System terminology is well established worldwide and in Pakistan.

1.6 International strategies: UN-CCD

United Nations Convention to Combat Desertification (UN-CCD) is one of the main environmental instrument initiated at the historic occasion of UNCED (United Nations Conference on Environment and Development) or Earth Summit at Rio de Janeiro on 3-14 June 1992 in Brazil.

CCD (1994) deals with land degradation problems in arid, semi-arid and dry sub-humid areas, in the result of natural factors such as drought, wind erosion, soil erosion and human interventions such as overgrazing, mismanagement in agriculture and irrigation practices.

Convention was adopted in June 1994 at Paris, by UN constituted INCD (Intergovernmental negotiating committee to elaborate a Convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa).

In February 1997, CCD entered into enforcement after 50th ratification. The Convention has various objectives, principles and 40 articles. This convention is global in scope, however, it has a very strong regional dimensions, as it has four regional annexure for Africa, Asia, Latin America and the Caribbean and Northern
Mediterranean region. According to CCD countries are supposed to develop National Action Programmes, which should involve all stakeholders, including Government agencies, local Government authorities, scientific institutions, NGOs, pastoral groups, farmers organizations, agricultural labourers, rangeland managers, women groups, youth and private sectors.

The Convention pioneers a democratic, bottom-up approach in international environmental law. It clearly emphasizes that the people who are facing desertification, best understand the fragile environments in which they live must be fully involved and be allowed to participate in the decisions that will shape their lives. The first principle of the treaty commits parties to ensure that decisions on the design and implementation of programme ...are to be taken with the participation of populations and local communities and that enabling environment is created at higher levels to facilitate action at national and local level.

District Councils and Union Councils can play an effective role in the implementation of the CCD in Pakistan. This is because of the fact that Union Councils and District Councils have sufficient mechanism and infrastructure to implement and monitor the CCD activities. Furthermore, they could also develop the infrastructure and raise funds to combat land degradation in their respective areas. Similarly, these councils can also be used as platforms for the capacity building and training of the NGOs, CBOs and VOs in the affected areas (Kazmi, 2000).

To support local communities in their own efforts in combating desertification and to draw on the knowledge and experience of the population concerned, ensuring the full participation of indigenous populations (Agenda 21). It is necessary to promote participatory management of natural resources, including rangeland, to
meet both the needs of rural populations and for conservation purposes, based on innovative technologies and sustainable development.

Desertification is one of the most serious environmental and socio-economic problems threatening the humankind on the eve of new age and millennium.

Disturbance of the natural equilibrium ultimately results in economical losses, social problems and general moral decline of the society. Degradation of natural and agricultural ecosystems has led to a deep environmental crisis. At all previous stages of its development, human society has tried to transform nature, with the aim to make it maximally complying to man's requirements. Presently any society has to transform its technology and psychology in such a way to comply with the requirements of environmental and economical sustainable (Babaev, 1999).

1.7 Water resources

Primary source of water is rainfall, which is the only source of sweet water in Cholistan. Rainwater is collected in natural depression or man-made ponds locally called “tobas”. There are 598 tobas in Cholistan (CDA, 1996) where desert dwellers collect and store rainwater from natural catchment. Dhars act as good catchment for rainwater harvesting. Water loss through evaporation from such ponded water was estimated as the highest as compared to seepage losses (Khan et al., 1990). The average rainfall in Cholistan is 100-200 mm. Most of the rainfall is received during monsoon season from July to September; however, some of it may fall during winter as well. A huge amount of water if harvested and stowed properly, not only enough for drinking of human beings and livestock but also much portion of water could be used for raising nurseries and forage.

Secondary source of water is groundwater, which is saline and not fit for drinking and agriculture purposes. Even brackish water is being used for livestock and other
domestic purposes. The aquifer in Cholistan is deep due to absence of canal system and rainwater recharge is negligible. Changes in water quality of wells take place according to type and amount of salts present in the parent material. Most of the groundwater resources are alkaline in reaction causing precipitation of Ca$^{2+}$, SO$_4^{2-}$ and CO$_3^{2-}$ ions and increasing the ionic balance of Na$^+$ and Cl$^-$ in water.

Groundwater, located at depths ranging from 30 to 90 meters is mostly saline, with salinity ranges from 368 to 35,000 mg/l (Baig et al., 1980) of total dissolved solids (TDS). Two major aquifers in Cholistan have sweet water but are surrounded by saline water (FAO/ADB, 1993). The first aquifer extents for 80 Km. from Fort Abbas towards Moujgarh, and is from 10 – 15 Km. wide. The aquifer lies between 40 to 100 meters below the surface and has an estimation volume of 10,000 million liters.

The second aquifer has its centre about 20 Km. northwest of Derawer Fort. It occupies an area of 50 Km$^2$, has a maximal thickness of 100 meters, and lies about 25 meters below the surface. This sweet aquifer is surrounded and underlain by bodies of brackish to saline waters (FAO/ADB, 1993).

Sweet water in Cholistan is also present in isolated lenses like Phulra, Moujgarh, Dingarh, and Derawer Fort along the abandoned Hakra River bed and Bhai Khan, Ghunnianwala, Islamgarh, Lakhewala and Renhal near Pak.-India border. Salinities of less than 1,900 total dissolved solids (TDS) at the latter three are more than suitable for human drinking, whereas livestock can tolerate levels as high as 15,000 TDS (table 13), or more in the case of camels.

Because of low and spatially erratic rainfall, water scarcity in Cholistan is endemic. Low rainfall, high infiltration in sandy soil and rapid evaporation preclude the establishment of permanent sources of surface water in the desert. However, shallow ephemeral lakes are formed in dhurs, which have highly
impervious loam or clay soils bottom, often of a saline or saline-sodic nature. The dhar is surrounded by sand dunes so that drainage ends blindly within the dhar.

Traditional methods of water resources control, storage and delivery include soil erosion prevention, rainwater harvesting, irrigation and drinking water-delivery structures, some of which have survived for many centuries. These structures, being long-lasting, indicate that advanced procedures had been followed in their design and construction. Thus, indigenous knowledge has neither been well documented nor scientifically analyzed in order to utilize it for supporting the sustainable development of rainfed, runoff and spate-irrigated farming.

1.7.1 Use of ground saline water for irrigation

Although the groundwater is saline but it can be used for saline agriculture to grow salt tolerant trees, vegetables, crops and fodder grasses in non-saline-non-sodic coarse textured soils with minimum adverse effects due to rapid leaching of salts beyond the root zone and flushing of salts from root zone by rains. Furthermore, dense saline-sodic soils can also be used for growing such palatable grasses, which are very salt tolerant and capable of surviving in soils having poor properties. The sandy and loamy soil that is about 1 million hectares can be brought under agriculture by using underground saline water and harvested rainwater.

Experiments showed that under certain conditions plant could not only survive but also even vast area of land could be irrigated with water of such high concentration. The soil is either sandy gravel or dune sand. Moderately saline irrigation water stimulates vegetation, assists the benevolent bacteria of the soil and improves yield and quality. Further, use of brackish water reduces soil evaporation, transpiration of plants and increases resistance to drought (Abdullah et al., 1990; 1991).
In Cholistan desert, about 0.44 million hectares are salt-affected low lying and clayey in nature soils, locally known as "elhars", where rainwater as well as saline groundwater could be utilized for growing salt grasses like Leptochloa fusca "kallar grass" as forage during summer. *L. fusca* is a promising candidate grass for economic utilization and better management of sodic, high pH, saline soil and saline water resources of Cholistan desert. *L. fusca* is known to be a versatile, halophytic, primary colonizer, easily propagatable, perennial, nutritive and palatable forage plant specie. It is judicious to utilize the land by using ground saline and surface rainwater resources for growing palatable grasses. Biological approach for economic utilization of salt-affected soil is feasible and is the only viable method when the soil is sodic and sweet water is not available for irrigation.

The cultivation of salt tolerant grasses would not only provide much needed palatable forage for livestock but also improve the physical properties of the soil due to biological activity of grass roots. The extensive and fibrous roots of grass can open soil, increase air exchange, release plant nutrients and the shoot foliage can increase organic matter, humus and soil mulching, decrease surface evaporation and improve physical properties of soil with the passage of time (Haq and Khan 1971; Joshi *et al.*, 1981; Abdullah *et al.*, 1986; Malik *et al.*, 1986 and Akhtar *et al.*, 1988).

### 1.8 Climate and vegetation cover

Cholistan falls within the arid subtropical continental monsoonal zone (figure 2). Its low rainfall is highly variable both in time and space (figure 3). The mean annual rainfall varies between less than 125 mm in the west and 200 mm in the east (figure 4).

Monsoonal rains in the form of heavy showers usually fall between July to September (figure 5), turning the desert into lush green. During the monsoons,
+PAKISTAN
RAINY DAYS

Number of Rainy Days in a Year

AFGHANISTAN

JAMMU & KASHMIR
(Disputed Territory)

N.W.F.P

PUNJAB

IRAN

BALUCHISTAN

SINDH

Arabian Sea

Cholistan Desert

SCALE
0  50  100  150 Km.

FIG. 3

PAKISTAN
Annual Rainfall

AFGHANISTAN
250 mm

N.W.F.P.
500 mm
250 mm

JAMMU
&
KASHMIR
(Disputed Territory)

500 mm
250 mm
750 mm
750 mm

250 mm

500 mm

250 mm

250 mm

125 mm

IRAN
125 mm

BALUCHISTAN

PUNJAB

125 mm

125 mm

250 mm

250 mm

125 mm

SINDH

250 mm

Arabian Sea

Cholistan Desert

SCALE
50 100 150 Km.

FIG. 4

vegetation growth, plant composition, biomass and plantability is better than rest of the year. Runoff is accumulated in temporary water holes (tobas), while the most quantity of water evaporates due to high temperature. After the monsoons, the range remains green for a short period. Aridity intensifies with gradual decrease in temperature, from 36°C to 14°C and vegetation cover considerably decreases, grasses and some shrubs dry out partially while forbs dry out completely. During the winter, a period between December and January, the temperature may fall from 27°C to 3°C. In this season some plants remain partially green are Calligonum, Haloxylon, Crótaíaria and Leptobene, providing forage for camels and goats.

The most common plants used as supplement of cereals are Cenchrus ciliaris, Cenchrus hirsutus and Cenchrus pivicum. These grasses are very widely distributed in Cholistan. During the famine and drought years, the seeds of these grasses are ground in flour and used as a supplement (Arshad et al., 1999).

The grains of Panicum antidotale, Panicum turgidum (Rao et al., 1989; Rao and Arshad, 1991; Arshad and Rao, 1994a) are also consumed as food during the famine years. Panicum antidotale and Panicum turgidum are very drought resistant and found on the high sand dunes and perpetuate by their hardy rhizomes and seeds. They also protect themselves from overgrazing because of their hard and unpalatable stubble. The seeds of both species are ground and mixed with other cereals.

Indigofera argentea is a wild legume and mostly found during the monsoon on the top of very high sand dunes of Greater Cholistan. During the drought years, the seeds of this herbage are also ground and mixed with other cereals.

There are seeds of many indigenous species, which posses considerably a high percentage of oil. Citrullus colocynthis is a perennial trailing herb with fruit of sandy tract, containing 15 percent of pulp, 23 percent rind and 62 percent seeds
(Sen, 1982). The seeds contain 21 percent of non-edible oil, whose paling is always brown in colour and very bitter in taste. Under natural conditions 50-80 creepers per hectare are recorded bearing 8 to 50 fruits per creeper. The oil obtained from this plant is used in the soap industry. It has high medical value for joint pains in human and stomach ailment in animals (Arshad et al., 1987).

The important plant species used as wind breaks and shelters belt are *Prosopis juliflora* (Valyati Kiker), *Tamarix aphylla* (Frash), *Prosopis cineraria* (Jandi) and *Acacia nilotica* (Kiker).

Cholistan is rich in vegetation resources that can be exploited on commercial basis. The area was once green and prosperous, where cultivation was practiced. The source of irrigation was Hakra River (Akbar et al., 1996). With the drying of the river, area was deserted through desertification processes and only few grazing lands were left.

### 1.9 Historical overview

Around 4000 BC Cholistan was a cradle of civilization commonly known as Hakra valley civilization, when Hakra River flowed through this region. The river supplied water until 1200 BC, about 600 BC it became irregular in flow and consequently vanished. The Hakra civilization, which flourished was one of the longest in the course of world history. *Aryans* were the indigenous people and the earliest civilization of the Indian subcontinent. In cultural advancement, it can be compared with the Mesopotamian, Egyptian and Babylonian civilization. Probably a variety of problems such as hostile invading contributed to the ultimate disappearance of this great civilization (Auj, 1995; Ahmad, 1999b).
The Cholistani people have inherited a rich cultural heritage from their ancestors, who dwelt for centuries in the Hakra Valley, which is now acclaimed as the force runner of the Indus Valley civilization.

Cholistan forms a part of the vast Indo-Gangetic Plain lying in a great tectonic trough which lies between the foothills of the Himalayan Mountains and the central core of South-Asia. This trough was subsequently filled up with the thick mass of alluvium derived from the Himalayan and deposited by the Indo-Gangetic system. This was transformed into a vast plain (FAO/ADB, 1993).

Geomorphologically, the Cholistan presents quite a complex pattern of alluvial and aeolian depositions, which was followed by: (a) wind resorting and further deposition of the sediments into various forms and sand ridges; (b) resorting and further deposition in spill channels; (c) deposition of clayey sediments in flats; and (d) present day wind resorting and dune formation. The westerly drifting of the rivers of the area combined with the lowering of the base level of erosion caused the formation of a number of terraces which also represent different depositional stages.

Based on differences in topographic form, parent material, soils and vegetation, Cholistan can be conveniently divided into two main geomorphic regions (figure 6); (i) Northern region, known as Lesser Cholistan (12,370 Km²), which constitutes the desert margin and consists of a series of saline alluvial flats alternating with low sand ridges/dunes; and (ii) Southern region, known as Greater Cholistan (13,960 Km²), a wind resorted sandy desert comprising of a number of old river terraces with various forms of sand ridges and inter-ridge valleys (FAO/ADB, 1993; Tahir et al., 1995).

Archaeological ruins present in Cholistan (figure 7) indicate that water availability in the area was higher a few centuries ago. The reduction of vegetation to about
one third or less of the rainfall, or even more, probably results in considerably higher near surface and surface temperature. As a result, evaporation of the scarce rainfall has increased considerably during the last decades so reducing the effective rainfall available for range and groundwater recharge, which is well known as self-reinforcing aspect of desertification. The aridity in Cholistan is rightly seen as a major limitation to wide-scale range improvement and management programmes. However, aridity prevents high incidence of many crops and livestock diseases as well as nutrient leaching from soils.

Desertification is the most complex problem of Pakistan but it can be monitored and controlled through scientific techniques rooted in rigorous and sophisticated methodology.

Last but not least, it is hoped that this study will help geographers and allied disciplines to enter into new millennium with grace and honour. I am confident that this study will give a priori model and structured format of data for the planners to overcome this menace identically found at many places in Pakistan.
relationship between the rivers and the development of civilization is best exemplified in the east central Indus Valley comprising the Cholistan desert of Pakistan (Mughal, 1992; Auj, 1995).

The Cholistani people have inherited a rich cultural heritage from their ancestors, who dwelt for centuries in the Hakra Valley, which is now acclaimed as the fore-runner of the Indus Valley civilization.

2.3 Archaic views about Hakra depression

The depression of Hakra is still visible in Bikaner, Bahawalpur (figure 12) and Sindh province. Its width is about two miles and length not less than 150 miles. Half of its course passes through Sindh, where the present Nara canal is, in fact the continuation of Hakra River. The map illustrated by Thomas Pennant, Hakra as rising in the Himalayas, east of the Sutlej and flowing down the town of Umerkot and ending into the Gulf of Kutch (Auj, 1995). There it is called Ghaggar.

Local people still remember the lost river in their folk songs and folklore. They tend to indicate some important phenomenon of the past, which even historians have failed to record. The lost river is now an event of the past but it still reverberates in the desert poetry. In fact, it looks very strange when even people sing about a river, they have never seen. The following prophecy about the lost river exists in the annals of Sindh.

"Haq whando Haero bhajandi bund Aror,
Bih machi on lorh wendi Sanme sukri"

"The Hakra shall become a perennial stream and dikes of Aror shall burst,
And thus shall production of lakes and streams be carried to the Sanmai clan as present"

"Hakra phir vi wahsi nadyan chulsin near,
Na jannum na janusi Sodha Rao Hamir"

"Hakra will flow again and its tributaries will be full of water,
But alas! A prince like Sodha Hamir will never be born again"
According to a Seraiki song, the inhabitants of Cholistan suffered two losses at the same time. First, the river dried up and secondly, their benevolent ruler Hamir, passed away. Hamir was the ruler of Pattan Munara, also known as Fatan, Patan Pur and Sej. The people of Cholistan reconciled with the loss of the river and hoped that it would flow again but the loss of Prince Hamir was lasting and could not be compensated (Auj, 1984b).

Such legends are very common in the annals of the Sindh and almost connected with each ruined city of the past.
Whitehead (1932) discussed the problem during canal survey levelling in the Punjab and opined that, the river Jumna at one time took a course in the westward, which is now represented by the beds of Chitang and the ‘Hakra’. Hakra and Nara formed a single independent river as far as the Rann of Kutch is concerned. In comparatively recent times the ‘Nara’ was separately fed by spill water from the Indus above Alor, but the Sutlej never contributed to the forming of the ‘Hakra’ (Auj, 1995).

In 1942, Sir Aural Stein surveyed the deserted course of the ‘Lost River’ (figure 13). He mentioned that, “It would be hazardous to co-relate the archaeologically attested changes of conditions along the Ghaggar-Hakra bed with reference found in the Vedic texts to the Saraswati River, but the evidence shows that down to historical times the Ghaggar carried water for irrigation under existing climatic conditions much farther than it does now. This makes it intelligible how the Saraswati has included in hymns of Rigveda to be praised as a ‘Great River’. The interval between the time, when the notion found expression in Vedic poetry and the time when the Ghaggar was joined by the branch of Sutlej, may not have been so great as to efface traditional knowledge of the entire river, having once been large enough to make its way as far as the Panjinad and the Indus. The width of the Ghaggar-Hakra bed is so great that even now it is mentioned in the local folklores. A great change has affected the Saraswati River or Ghaggar since reference was made in Vedic texts, which is scarcely composed before the second millennium BC at the earliest. This change may be attributed to two distinct physical causes. As regards the upper portion of the ancient bed, archaeological evidence attests a drying up during historical times, which is likely to have been at work in prehistoric periods. It might have been hastened by the diversion of floodwater for irrigation, brought about by more settled conditions and the resulting pressure of
ARCHAEOLOGICAL SITES IN CHOLISTAN
population". Down on the Hakra, the main change was due to the Sutlej having in late prehistoric times, abandoned bed, which before had joined the Ghaggar, the result of a law, affected all rivers course lies over alluvial plains. We have clear evidence that the drying up was gradual, at least in the historical period (Stein, 1942).

Ghosh’s (1953) report on "Exploration in Bikaner" was read in the All-India History Conference in 1951 at Jaipur. He says, "In Bikaner, the dried up bed (Hakra) is clearly traced in a westerly direction until it reaches the town of Hanumangarh, renamed in the last decade as Sadulgarh, but anciently known as Bhatner. Here the channel is met by another, from the northwest, now known as Naiwala, identified as ancient bed of Sutlej, which formed the part of Saraswati system and had not captured the Beas, thus to flow into the Indus in ancient times".

Beyond Suratgarh the river, as indicated by the sandbanks now attaining great heights, flowed past another but smaller town of Anupgarh and beyond 6 miles or so is Bahawalpur.

In the Saraswati Valley, colossal mound of Kali Bangan stands, as it were as the eastern most outpost of this great culture. The discovery of these mounds brings the Harappan culture much nearer to the heart of India and reveals how deeply it had taken its roots in the Indian soil (Ghosh, 1953).

Wilhelmy (1969) examined and suggested during the 1960s that from the Tertiary times the drainage of North India was very different to that of the present day, which has been influenced by the up-thrust of Himalayas. In more recent geological times (Late Pleistocene and Early Holocene), there were three major river systems; Indus, Saraswati and Ganges. The Saraswati flowed in the Ghaggar-Hakra channel, receiving water of both the Ur-Jumna and the Sutlej (figure 14). In
Rigvadic times (around 1000 BC) the Ur-Jumna had already been captured by the Ganges system, and in Mahabharat (around the beginning of the Christian era) the water of the Sutlej was largely captured by the Indus. Wilhelmy (1969) suggested that the Ghaggar or Hakra channels continued to serve as flood channels of the Sutlej and the Indus, which were utilized for irrigation (Allchin et al., 1978).

The ‘Lost River’ played a vital role in the demise of Hakra Valley civilization after it dried up or changed its course. Geographers are still trying hard to find the real cause of disappearance of Hakra River keeping in view, its traces, depressions, chronology of physical changes and geographical history of the region where the river once flowed.

Once, the Cholistan Desert was rich in all kinds of wildlife, including magnificent mammals like rhinoceros, lions, leopards and a number of beautiful game birds. There is evidence that hunting of lion, leopard, deer (pahra), and ravine-deer (hiran) wild boars were common. Lion and leopard had disappeared from the desert by the beginning of this century. Black buck (kala hiran), chinkara, nilgai and bustards are now the most threatened species, however, large herds are found across the border. Similarly, wild ass has been encountered near Pak. – India border but its number is dwindling fast. Desert cat and wild boar have almost disappeared, whereas hare and other rodents are still found. Among birds, some species of partridges, quails and sand grouse are found.

Cholistan was once green and prosperous land, where cultivation was practiced. The source of irrigation water was Hakra River (Akbar et al., 1996). With the drying of the river, area was deserted through desertification processes and left only as grazing lands.
Cholistanis live precarious existence, praying for rain. With a meager average annual rainfall varies between 100-250 mm and the high temperature, scaling up the barometer to 51°C, the evapo-transpiration rate in the desert stands at a high 300 centimeters a year. This is ten times the rate of rainfall, making large tracts of the area extremely arid and barely habitable.

Drinking water is the most acute problem in the region. Groundwater lies at the depth of 80 to 120 feet, is extremely brackish and cannot be used even by the livestock.

The people of Cholistan have three kinds of prayers. They pray for the clouds to appear and the rain to fall. When the clouds appear they pray for the wind, not to blow as it drives them away. When the rain occurs and there is water all around, they pray for wind to blow as it dries the paths, so that the stranded caravans and herds of livestock can move again.

In fact, Masson has given a true picture of Cholistan. In the rainy season, ponds "tobas" were filled with water, there was grass on sand dunes, bushes and stunted trees provided food for camels, cows, sheep and goats. Temporary settlements always encircle and rohillas keep on moving from place to place in search of better grasslands. In winter, they return to their permanent settlements. Their life is hard but not without rewards. The desert has more attraction for rohillas. They love its mystique. "The one who leaves the desert is like a tree which has been uprooted. Can a tree survive without roots?" The dwellers of this desert ask.

The relationship of the animals with the people is particularly close, one cannot live without the other. They live on the milk of the cows and goats. Sometimes curd is put to novel uses, one of them being the service of flute. The shepherds fill up the hollow of the flute with curds. They allow the curd to stay a few days inside
the hollow. When they finally shake the card out, they think that the sound of the flute has become mellow and indeed, it is fit to be used for rendering all kinds of tunes on it.

A vast majority of the population of Cholistan continues to lead a nomadic existence, and for the small proportion of the population, who has chosen to settle down to agriculture, the dramatic changes have proved traumatic in many ways. The vastness and beauty of Cholistan still haunts the people who have moved from the desert to settle down in chaks on its peripheries. But the radical change in their circumstances following their switch from a nomadic to a peasant way of life is seen as a mixed blessing by most of the desert people.

The nomads of the parched, thirsty land of Cholistan, who are denied the fruits of overall development of the country, are living a Stone Age existence. They do not have access to the most basic facilities such as clean drinking water, food and basic health care.

In the vastness of the Cholistan desert, the Hindu Bhaggats, mostly Maighwal and Bheels, are keeping alive the tradition of music, dance and versification, all being very much part of the spirit of the Hakra civilization.

Cholistan offers tremendous opportunities for those seeking to gain a deeper understanding of its rich cultural heritage. As one expert puts it, the area has a "unique romanticism, distinguished poetry, literature, folklore and music".

2.4 Khawaja Farreed: The Desert Poet

The region of Cholistan had a powerful influence over Seraiki poetry and literature. The great 19th century's Seraiki poet, Khawaja Ghulam Farreed, who fell in love with a Cholistani Maiden, used Rohi as a metaphor for beauty and love.
Cholistan or Rohi is the main theme of his poetry. The Khawaja's concept of Cholistan:

Seldom there a tree is found
A barren waste out of bound;
Where the herbs and hedges to
Grow afar and very few;

Many of his poems describe the beauty he experienced in the desert, particularly during the brief seasonal flowering in the months of rains. In fact it is the spectacle of the desert in rains which called forth his most vivid lyrics and songs describing the beauty of nature:

'My far-off love, the wind blows!
The coming of the rains has made
Each desert shrub, a blooming rose'.

In another rain song he says:

"The darkling clouds which come from far,
From east and south, and from Marwar.
These gusts from every quarter are
Of coming rains the prophecies".

Khawaja's desert songs seem to be the straightforward didactic messages for the Cholistani nomads, which are in fact profound both in his teaching and his mystical awareness. For example, his famous kafi, 'Pili-pickers', seems outwardly to be a call for picking this desert fruit but in fact it is the message for unity. The real quality of Khawaja's poem is their rhythmic perfection. Now all of them are the heritage of the desert in the form of folklore and folk songs (Auj, 1984c).

The people of Cholistan say, "We are not happy with our present way of life, we love every inch of Rohi, which is inhabited due to blessings of Khawaja Ghulam Fareed. This (settled) life does not suit us, and farming is very hard".
The land of golden sand and white sunshine has a great attraction for Arab rulers. They feel pleasure as they are in their own home in the shades of its oases. For an Arab, Cholistan provides all the attraction he needs.

2.5 Conclusion

Cholistan was once green and prosperous land, where cultivation was practiced. The source of irrigation water was Hakra River. The river supplied water until 1200 BC, about 600 BC it became irregular in flow and consequently vanished. The Hakra civilization, which flourished was one of the longest in the course of world history. Cholistan is the only place where the remains of the oldest settlements are still intact because of the desertion of the river Hakra. With the drying of the river, area was deserted through desertification processes and left only as grazing lands.

Archaeological ruins present in Cholistan indicate that water availability in the area was higher a few centuries ago. The reduction of vegetation to about one third or less of its historical cover most probably results in considerably higher near surface and surface temperature. As a result, evaporation of the scarce rainfall has increased considerably during the last decades so reducing the effective rainfall available for range and groundwater recharge, which is well known as self-reinforcing aspect of desertification. The aridity in Cholistan is rightly seen as a major limitation to wide-scale range improvement and management programmes. However, aridity prevents high incidence of many crops and livestock diseases as well as nutrient leaching from soils.
CHAPTER - 2

HISTORICAL BACKGROUND OF CHOLISTAN

2.1 Introduction

The word 'Cholistan' has been derived from a Turkish word, 'Chol', means a desert, while some historians believe that this name has been distorted from Iraqi (Kurdish) word, 'Chilistan' meaning waterless waste land (Ahmad et al., 1992; Auj, 1995 and Ahmad, 1998a; 1999b), popularly Cholistan is known as 'Rohi'. In a dialect still spoken in some parts of Tibet, 'roh' means a hill, from which the name Rohilla has been attributed. In fact, Rohi has been derived from the Pushto word 'roh', meaning is a sandy desert (Auj, 1987a; 1991; Ahmad, 1999d).

2.2 Cholistan: Cradle of Hakra Valley Civilization

Around 4000 BC Cholistan was a cradle of civilization commonly known as Hakra valley civilization, when Hakra River flowed through the region. The river supplied water until 1200 BC, about 600 BC it became irregular in flow and consequently vanished. The Hakra civilization, which flourished was one of the longest in the course of world history. Aryans were the indigenous people (Auj, 1987b) and the earliest civilization of the Indian subcontinent. In cultural advancement it can be compared with the Mesopotamian, Egyptian and Babylonian civilization (figure 8). Probably a variety of problems such as hostile invading contributed to the ultimate disappearance of this great civilization (Ahmad, 1999c).

Dera wer (plate 1) a well known historical place of the region was the capital of Jats in Cholistan. In fact, it is the only Dravidian settlement which has so far survived in the Hakra civilization. Many other names have been assigned to this
The fortification of Derawar Fort. View from southwestern corner

Plate 1
settlement from time to time like Dilawar, Derajat and Dera-rawal. Its real
Dravidian name Derawer has survived from the time immemorial. The ruins of
Derawer Fort near the dried bed of Hakra River still lie in the heart of Cholistan
(Auj, 1998).

The phenomenon of disappearance of the mighty river Hakra or Ghaggar is
supposed to be the prehistoric times, hardly left some clue to the geographical
change, resulted in the desolation of two thirds of the area of Bahawalpur region.
In spite of its fading past, this legendary river is still remembered by geographers
as the ‘Lost River’, identified by “Sacred River Saraswati” in the hymns of
Rigveda, also praised as “the chief and purest rivers flowing from the mountains to
the ocean” (Auj, 1987b). According to Mahabharat it has been called “one of the
two divine rivers forming the northern boundary of Darma Khestra (Holy Land)”. The first Aryan settlement was also established on its bank.

Rohillas can be presumed that they were under the constant pressure of the
invading Aryans, Jats, Baluchis and Iranians. Their social structure has not still
changed. One possible reason is the desertion of the Hakra River, which made this
place inhospitable. Invaders seem to have come and gone, leaving the locals to face
the cruelties of nature. In the year 1842, the famous traveller, Charles Masson,
visited Cholistan. According to him, “of course the portion of desert stretching in
eastward of Bahawalpur to Bikaner is little productive. Amongst other inhabited
localities, the town of Phulra, Marut and Mauj Garh drive a considerable trade of
grain with the neighbouring states. In this tract, camel thrives exceedingly, and
there is ample sustenance in the prickly and saline plants, which cover the surface.
These were also wanted by numerous herds of horn cattle, however, shifting their
positions, being guided by the convenience of water. In certain seasons of year, the
proprietors abandon their villages, abode temporarily in the spots they select, as in
Bikaneer. The traveller finds abundance of milk and butter, some times he might not procure in the villages. In remote times river flowed, fertilized and sterilized the country. Numerous vestiges of its beds, in the form of burned bricks and fragments strewed in the soil of ancient towns, are found” (Auj, 1995).

The present Cholistan is known as ‘Ragey Des’, the land of warriors. In the institutes of Akbar, (Aine-e-Akbari), tribes are named Ashambetty by Abul Fazal (Auj, 1987a). The tribes of Joviyas are considered the ancient Yaudheyas or warriors of the Jungle Des or forestland, which now settled in Hariana, Bhatner and Nagar areas. During Alexander’s stay at Uch, the warlike tribes of Sambroacae or Sambagracae were supposed to be the present Bhatis of Jaisalmir, the Bagris of Bikaneer, and the Joviyas settled on the bank of the Sutlej. Pliny, a famous historian in his list of about 30 tribes of the Indus plain Jains, the oldest inhabitants of India are still found in Cholistan. Although they are small in number, yet their presence indicates the antiquity of the place. Mortimer Wheeler (1953) says that amongst the ruins of Indus cities, the cemetery known to archaeology as the “Cemetery of Culture” has only been identified at Cholistan. In the Indus plain, Cholistan is the only place where the remains of the oldest settlements are still intact because of the desertion of the river Hakra. Most of the remains still bear their ‘Sanskrit’ names like Ghaggar, Hakra, Marot, Phulra and Wanj-rut, now called Bijnot and Vinjot. Wanj-rut is supposed to be the Pichenpolo, mentioned by the Chinese pilgrim, Huen Thsang, as the capital of Sindh in the seventh century. In ancient times, it was situated on the eastern bank of the Hakra River. Marot, one of the oldest settlements of the Indus Valley was situated on the road, connecting Delhi with Multan (Auj, 1995).

In Cholistan, the relics with Aryan names are Siw-rai, Pattan Munara and Walhar. Cunningham (1875) identified Siw-rai while Greek historian identified Sodrai or
Sogdoi (Auj, 1984a). Pattan Munara, the remains of a Buddhist monastery still exit in Cholistan.

Mau in Rahimyar Khan district is another ancient town, a name according to General Haig (1972), suggested a possible connection with Mousikunos. Some historians connect it with Mushika, a tribe mentioned in Vishnu Puran. Mau is in fact, an ancient Aryan word having the meaning “the moon” (Auj, 1987b).

Derawer, the earliest settlement of the Indus Valley and the only habitation that has survived up till now, is also in Cholistan. According to Mughal (1997), the highest concentration of older Indus sites exists here (figure 9). At Ganweriwala (National Geographic, 2000) near Derawer, he discovered ruins of a town (larger than Harappa); which was almost as large as Moenjodaro (figure 10), all suggestive of stable means of subsistence. In the same region are represented all the known development stages of the Indus Civilization, the Early Harappan, the Mature Harappan, and the Late Harappan. On present evidence, it would seem that sometime around the middle of the second millennium BC hydrographic changes that were operative since at least the third millennium had substantially reduced or cut-off the river water-supply to the Hakra. The population settled alongwith Hakra were forced to move out and resettle near the upper course of the Ghaggar and its tributaries, to the north and the northeast of Cholistan, where water was still available perennially or with seasonal regularity. This site when excavated was sure to reveal the hidden mysteries of civilization that was larger than the Babylonian or the Egyptian empires.

Archaeologically and historically, another place of great importance is Uch, built by Alexander. The town was then named as Askaland Usah. Cunningham supposed it to be the Iskander of Chachnameh, which was taken by Chach on his voyage against Multan. In the 12th century, Uch was known as Deo-garh.
Changes in the courses of the Indus (figure 11) and the Hakra River system of the Indus Valley have profoundly influenced the settlement patterns and have induced significant cultural changes which have not been documented archaeologically. The evidence suggest that the origin, climax and decline of the Indus Valley Civilization between the late fourth and second millennium BC, were intimately linked with the environmental changes generated by the shifting river regimes. The
OLD COURSES OF THE INDUS

I Prehistoric, 3000 B.C.
II Greek, 3rd. Century B.C.
III Arab Times, 8th. Century A.D.
IV Middle Ages.
IVA British.

CHAPTER - 3

EXTENT OF DESERTIFICATION

3.1 Overview

The term run-off collection is used to describe the process of collecting and storing water for later beneficial use from an area that has been modified or treated to increase precipitation run-off. Runoff farming is the complete facility for collecting and storing the run-off water (Frasier, 1994).

The first run-off collecting facility was in all likelihood nothing more than a depression in a rock surface that trapped rainwater. The collected water served as a drinking water supply for man and animals. These water depression storages are still found in many parts of the world and serve as drinking water supply. Probably the first constructed water-harvesting facility was simply an excavated pit or other water storage container placed at the out fall of a rocky ledge to catch run-off water during a rainstorm. The next evolutionary step might have been to construct a rock diversion wall or gutter to provide a larger collection area. Researchers have found signs of early water harvesting structures believed to have been constructed over 9000 years ago in the Edom mountains in southern Jordan (Bruins et al., 1986). There is evidence in Iraq that simple forms of water harvesting were practiced in the Ur area in 4500 BC. Along desert roads, from the Arabian Gulf to Mecca there still exist water-harvesting systems that were constructed to supply water for trade caravans (Hardan, 1975).

One of the earliest documented complete run-off farming installation is located in the Negev Desert of Israel. These installations have been built about 4000 years
ago (Evanari et al., 1961). The runoff area for these systems was upland hillsides, which were cleared of vegetation, and the soil smoothed to increase precipitation runoff. Contour ditches conveyed to collect water for irrigating lower-lying fields. These systems provided an irrigated agriculture to an area that today has an average annual precipitation of approximately 100 mm. There is evidence that similar systems were used 500 years ago by the Native Americans in the southwestern region of the USA (Woodbury, 1963). Evidence of other ancient water-harvesting systems has been uncovered in Northern Africa. There is an uncertainty as to why most of these systems were abandoned. Maybe the conveyance systems became clogged with silt or possibly the soils in the crop growing areas became infertile due to increased salinity. Others have speculated that some form of political instability or maybe a climate change in the areas forced the abandonment of the systems (Shanan and Tadmor, 1979).

Traditional methods of water resources control, storage and delivery include soil erosion prevention, rainwater harvesting, irrigation and drinking water-delivery structures, some of which have survived for many centuries. These structures, being long-lasting, indicate that advanced procedures had been followed in their design and construction. Thus, indigenous knowledge has neither been well documented nor scientifically analyzed in order to utilize it for supporting the sustainable development of rainfed, runoff and spate-irrigated farming.

The people of Cholistan depend on the rainwater, which is collected in natural depressions or man-made ponds locally called 'TOBAS' during rainy season (figure 15). There are 598 tobas in Cholistan (CDA, 1996). These tobas are not located at appropriate places. As a result, water is flushed-out rapidly and cannot be used for longer period. These tobas supply water maximum for three to four
months. Major water losses from the tobas are seepage and evaporation. The cleaning of tobas is also not done regularly, which also reduce the water storage capacity (Akram et al., 1995; Chaudhry, 1995 and Correspondent Dawn, 2000).

In Cholistán, the catchment area lies adjacent to the fields on same level, it is known as micro-catchment system. The runoff water flows only a short distance. Micro-catchment systems are effective for use in growing trees, shrubs, collecting rainwater and precipitation (Pacey and Cullis, 1986).

The climate of Cholistán is arid, sub-tropical continental type, characterized by low and sporadic rainfall, high temperature, low relative humidity, and high rate of evaporation and strong summer winds. Most of the rainfall is received in the month of July and September (figure 16) but some of it also falls in winter. The annual rainfall varies between 100-250 mm but sometimes it exceeds 250 mm (table 10). The evapotranspiration rate in the desert stands at 300 centimeters a year, which is ten times the rate of rainfall, making large tracts of the area extremely arid (table 2, figure 17 a,b,c) and barely habitable.

Categorization of desertification is not hard and fast. Nevertheless, we can classify the desertified land on the basis of international indicators. As Cholistán is being classified in three categories according to the intensity of desertification, these are:

- Very severe desertification,
- Severe desertification,
- Moderate desertification.

Very severe desertification is extended over 441,900 hectares in small scattered patches lie in north and north-eastern Cholistán (Lesser Cholistán). The region comprises on saline-sodic clayey soil, poor vegetation cover (20-50%) is found at
some places like Lalsuanra, Chak 373, Mouj Garh, Fazilwala Toba, Khotewala Toba, Pathaniwala Khu and Winjor Toba (figure 17c and figure 18).

Severe desertification is extended over 2,079,400 hectares and lies in southern Cholistan (Greater Cholistan). The region comprises on sand dunes and sandy soil whereas wind erosion is the major problem. Vegetation cover (20-50%) is found in Greater Cholistan at Bahuwala Toba, Islami Garh, Nuniewala Khu, Kakiwala Toba, Khera Toba, Gurarewala Toba and Nawan Kot.

Moderate desertification region lies in southern Cholistan (Greater Cholistan). In this region the vegetation cover is 5-20%, the soil is non-saline non-sodic loamy, covering an area of 58,700 hectares. Low vegetation cover, sodicity, extreme climatic conditions and wind erosion are the serious problems of this region. The summer winds are stronger than the winter winds. The winter cold winds sometimes cause mortality among the flocks.

The study reveals that severe wind erosion is the major contributor to desertification in Cholistan (table 2, 3 and 4, figure 17 a,b,c). Furthermore, desertification map of the drylands of Asia (Kharin et al., 1999) shows that Cholistan lies in RE3 category (figure 19) and also indicates very severe wind erosion in the rangelands. The map is carefully complied with the help of space images, remote sensing data and regional map of semi drylands and drylands of Asia (Kharin et al., 1993).
Fig. 19

PORTION OF PAKISTAN AS TAKEN FROM DESERTIFICATION MAP OF THE DRYLANDS OF ASIA

SOURCE: Kharin et al., 1999.
Table – 2
EXTENT OF DESERTIFICATION

<table>
<thead>
<tr>
<th>Desertification Class</th>
<th>Extent (Hec.)</th>
<th>Percentage</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>58,700</td>
<td>2.0</td>
<td>Wind erosion, vegetation cover, sodicity, and climatic condition.</td>
</tr>
<tr>
<td>Severe</td>
<td>2,079,400</td>
<td>81.0</td>
<td>Vegetation cover, soil physical properties, wind erosion and climatic condition.</td>
</tr>
<tr>
<td>Very severe</td>
<td>441,900</td>
<td>17.0</td>
<td>Sodicity, vegetation cover, soil physical properties.</td>
</tr>
<tr>
<td>Total</td>
<td>2,580,000</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: PADMU - Pakistan Desertification Monitoring Unit, 1986.

Extreme aridity (Ansari, 1998), predominantly sandy nature of the soils (table 3, figure 20), topography and extreme deficiency of drinking water as well as non availability of fresh water for irrigation are main factors which did not allow the area to be used as an arable land (table 4).

Table – 3
TYPES OF SOIL AND WIND EROSION

<table>
<thead>
<tr>
<th>Soil Types</th>
<th>Extent (Hec.)</th>
<th>Percentage</th>
<th>Wind Erosion</th>
<th>Extent (Hec.)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline sodic clayey soils (Dhars)</td>
<td>441,900</td>
<td>17.0</td>
<td>Non or slight</td>
<td>441,900</td>
<td>17.0</td>
</tr>
<tr>
<td>Loamy soils</td>
<td>58,700</td>
<td>2.0</td>
<td>Moderate</td>
<td>58,700</td>
<td>2.0</td>
</tr>
<tr>
<td>Sand dunes</td>
<td>1,131,900</td>
<td>44.0</td>
<td>Severe</td>
<td>2,079,400</td>
<td>81.0</td>
</tr>
<tr>
<td>Sandy soils</td>
<td>945,500</td>
<td>37.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2,580,000</td>
<td>100.0</td>
<td></td>
<td>2,580,000</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: After Pakistan Desertification Monitoring Unit, 1986.

Table – 4
VEGETATION COVER

<table>
<thead>
<tr>
<th>Vegetation Cover</th>
<th>Extent (Hec.)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good vegetation (20 – 50%)</td>
<td>525,000</td>
<td>20.0</td>
</tr>
<tr>
<td>Moderate vegetation (5 – 20%)</td>
<td>1,613,100</td>
<td>63.0</td>
</tr>
<tr>
<td>Poor vegetation (&lt;5%)</td>
<td>441,900</td>
<td>17.0</td>
</tr>
<tr>
<td>Total</td>
<td>2,580,000</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Drinking water and storage of forage grasses are the main causes of low yield of livestock. When there is no rain during the year, then water and fodder become very severe problem for the people and livestock. As a result of drought, the people are compelled to leave the area in search of water and fodder. They migrate towards irrigated lands. They stay there till the rains occur in Cholistan. After rains, Cholistan becomes green and rich in forage grasses. Consequently, carrying capacity of ranges increases and more production from livestock is achieved.

The quantity of precipitation required to yield runoff is known as the threshold precipitation and this varies with terrain and vegetation cover as well as soil characteristics. It is quite possible for a locality to have frequent light showers, which fail to exceed the threshold and simply evaporate or soak away. Special treatments may reduce infiltration or render the surface hydrophobic and so make rainfall collection possible in localities with unsuitable soils, treatment can also improve the collection efficiency of existing, untreated catchment. The problem is to find and apply an effective, sufficiently cheap, durable and non-harmful compound (Hutchinson et al., 1981).

3.2 Topographical form and runoff collection

The features of soil profile located in the Northwest of Ramewala toba (table 5) in the vicinity of Dingarh Fort shows that texture of soil profile is clay loam to silty clay up to 34 Cm depth, while the remaining depth of the profile up to 150 Cm consists of loamy very fine and sand textures. The soil horizon (cb) from depth 34 to 67 Cm is buried and soils horizon (cg) from depth 90 to 110 Cm is glayed. The structure of the profile is between massive and sub-angular blocky characteristics. The pores in the top horizon (A) of the profile from soil surface to 6 Cm depth are common fine vesicular types. These pores are not continuous; therefore,
infiltration of water will not go deep. The pores in other horizons of the profile are absent. The pH of the profile is between 8.8 and 9.0. Due to high sodicity in the profile, the soil horizons are devoid of porosity. Mottles and roots are also absent in the profile. The soil profile up to 110 Cm consists of CaCO₃ in the form of common very fine to fine lime nodules and a few lime kankers that also cause hardness. The profile from soil surface to 34 Cm depth is hard to very hard. The horizon from 90 to 110 Cm is glayed indicating once it was under water, as a result there is no pore space. The characteristics of the profile indicate that the soils are non-porous and non-drained to very poorly drained. It indicates that this area is very suitable for rain runoff collection.

Table – 5

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil depth (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture</td>
<td>Clay loam</td>
<td>Silty clay</td>
<td>Loamy very fine sand</td>
<td>Loamy fine sand</td>
<td>Loamy fine sand</td>
<td>Loamy very fine sand</td>
</tr>
<tr>
<td>Structure</td>
<td>Massive</td>
<td>Subangular blocks</td>
<td>Massive</td>
<td>Massive</td>
<td>Massive</td>
<td>Massive</td>
</tr>
<tr>
<td>Pores</td>
<td>Common fine vesicular</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>pH</td>
<td>8.8</td>
<td>9.0</td>
<td>9.0</td>
<td>8.8</td>
<td>8.8</td>
<td>8.8</td>
</tr>
<tr>
<td>Mottles</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Roots</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>Common very fine nodules</td>
<td>Common fine nodules</td>
<td>Common fine and a few fine kankers</td>
<td>Common very fine lime nodules</td>
<td>Common very fine lime nodules</td>
<td>Nil</td>
</tr>
<tr>
<td>Hardness</td>
<td>Mvwd</td>
<td>Very hard</td>
<td>Soft</td>
<td>Trifle</td>
<td>Trifle</td>
<td>Very trifle</td>
</tr>
<tr>
<td>Glayed soil</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Buried soil</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Source: PADMU - Pakistan Desertification Monitoring Unit.

The features of profile located 2.37 Km. from Dingarh Fort on Barianwala toba (table 6) track towards west. The characteristics of this profile mostly resemble to
profile under table 5 except some features. The depth of buried horizon is more and profile does not contain gleyed horizon. The profile is consisting of common very fine to fine mottles indicating that these soils once had been under water. This profile also indicates that the area in non to very poorly drained therefore, very appropriate for runoff harvesting and collection.

Table - 6

PROFILE CHARACTERISTICS AS A CATCHMENT FOR RAINWATER HARVESTING LOCATED ABOUT 2.37 Km. FROM DINGARH FORT ON BARIANWALA TOBA TRACK, ABOUT 500 METERS TOWARDS WEST OF THE TRACK

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Horizon</td>
<td>D - R</td>
<td>8 - 35</td>
<td>35 - 90</td>
<td>90 - 150</td>
<td></td>
</tr>
<tr>
<td>Texture</td>
<td>Clay loam</td>
<td>Silty clay</td>
<td>Loamy very fine sand</td>
<td>Loamy fine to fine sand</td>
<td></td>
</tr>
<tr>
<td>Structure</td>
<td>Massive</td>
<td>Subangular blocky</td>
<td>Massive</td>
<td>Massive</td>
<td></td>
</tr>
<tr>
<td>Type of pores</td>
<td>Vesicular</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>No. of pores</td>
<td>Common fine</td>
<td>9.0</td>
<td>9.0</td>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>Mottles</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>No. of mottles</td>
<td>Nil</td>
<td>Common fine</td>
<td>Many fine</td>
<td>Many fine</td>
<td></td>
</tr>
<tr>
<td>Roots</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>CaCO₃</td>
<td>Common fine</td>
<td>nodule nodule</td>
<td>Common fine to a few medium kankers</td>
<td>Common very fine line kankers</td>
<td></td>
</tr>
<tr>
<td>Hardness</td>
<td>Hard</td>
<td>Very hard</td>
<td>friable</td>
<td>friable</td>
<td></td>
</tr>
<tr>
<td>Gleyed soil</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Buried soil</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Source: PADMU - Pakistan Desertification Monitoring Unit.

The features and characteristics of profile located half Km. North-west of Dingarh Fort (table 7), shows that the texture of the profile is between clay loam to silty clay up to 125 Cm depth and remaining profile up to 150 Cm is buried having coarse textured fine sand. The major part of the profile consists of B-horizons indicating developed soils. The structure of the profile is massive to sub-angular blocky. The profile up to 9 Cm depth is consisting of common fine vesicular pores, while up to depth 108 Cm are a few fine to very fine tubular pores. The pH of the profile is between 9.0 and 9.2 indicating very high sodicity. The profile is
consisting of common fine to many fine to medium mottles indicating that once this area was under water and it caused reduction of iron and manganese. Mottles also indicate that these soils are non-porous. The profile is devoid of roots except a few fine roots in the horizon B21 from depth 9 Cm to 75 Cm. The profile is hard to very hard up to depth 125 Cm. The features of the profile indicate that the area is very poorly drained and suitable for rainwater harvesting and collection.

Table – 7

<table>
<thead>
<tr>
<th>Soil Horizon</th>
<th>A</th>
<th>B21</th>
<th>B22</th>
<th>B23</th>
<th>Cb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Depth (Cm)</td>
<td>0 - 9</td>
<td>9 - 75</td>
<td>75 - 108</td>
<td>108 - 125</td>
<td>125 - 150</td>
</tr>
<tr>
<td>Texture</td>
<td>Clay loam</td>
<td>Silty clay</td>
<td>Silty clay</td>
<td>Silty clay</td>
<td>Fine sand</td>
</tr>
<tr>
<td>Structure</td>
<td>Massive</td>
<td>Sub-angular blocky</td>
<td>Sub-angular blocky</td>
<td>Sub-angular blocky</td>
<td>Sub-angular blocky</td>
</tr>
<tr>
<td>Type of pores</td>
<td>Vesicular</td>
<td>Tubular</td>
<td>Tubular</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>No. of pores</td>
<td>Common fine</td>
<td>A few very fine</td>
<td>A few very fine</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>pH</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.2</td>
</tr>
<tr>
<td>Mottles</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No. of mottles</td>
<td>Nil</td>
<td>Common fine</td>
<td>Common fine</td>
<td>Many fine</td>
<td>Common medium</td>
</tr>
<tr>
<td>Roots</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>No. of roots</td>
<td>Nil</td>
<td>A few fine</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Hardness</td>
<td>Hard</td>
<td>Very hard</td>
<td>Very hard</td>
<td>Very hard</td>
<td>Fragile</td>
</tr>
<tr>
<td>Glazed soil</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Buried soil</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Source: PADMU - Pakistan Desertification Monitoring Unit.

The features and characteristics of profile located 200 meters South-west of Bachewala toba (table 8) are mostly similar to profile located about 500 meters North-west of Dingarh Fort except some minor features. This profile indicates that the area is very poorly drained and very suitable for rainwater harvesting and collection.
The features of profile located about 4.15 Km. from Dingarh Fort on Gappenwala toba (table 9) track about 500 meters towards East are almost similar to the profiles located about 200 meters South-west from Bachewala toba and the profile located about 500 meters North-west of Dingarh Fort, except minor difference. Therefore, this area is also a good catchment for rainwater harvesting and collection.

Table – 8

PROFILE CHARACTERISTICS AS A CATCHMENT FOR RAINWATER HARVESTING LOCATED ABOUT 200 METERS SOUTH-WEST FROM BACHEWALA TOBA

<table>
<thead>
<tr>
<th>Soil Horizon</th>
<th>A</th>
<th>B1</th>
<th>B2</th>
<th>Cb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Depth (Cm)</td>
<td>0 - 8</td>
<td>8 - 50</td>
<td>50 - 70</td>
<td>70 - 150</td>
</tr>
<tr>
<td>Texture</td>
<td>Silty clay</td>
<td>Silty clay</td>
<td>Silty clay</td>
<td>Loamy sand</td>
</tr>
<tr>
<td>Structure</td>
<td>Massive</td>
<td>Sub angular blocky</td>
<td>Sub angular blocky</td>
<td>Sub angular blocky</td>
</tr>
<tr>
<td>Type of pores</td>
<td>Few fine vesicular</td>
<td>A few very fine tubular</td>
<td>A few very fine tubular</td>
<td>No</td>
</tr>
<tr>
<td>pH</td>
<td>9.0</td>
<td>9.2</td>
<td>9.0</td>
<td>9.2</td>
</tr>
<tr>
<td>Motiles</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No. of motiles</td>
<td>Nil</td>
<td>Common line</td>
<td>Common line</td>
<td>Common line</td>
</tr>
<tr>
<td>Roots</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>No of roots</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Common line to common medium kankers</td>
</tr>
<tr>
<td>Hardness</td>
<td>Hard</td>
<td>Very hard</td>
<td>Very hard</td>
<td>Frangible</td>
</tr>
<tr>
<td>Gleyed soil</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Buried soil</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Source: PADMU - Pakistan Desertification Monitoring Unit.
### Table - 9

**PROFILE CHARACTERISTICS AS A CATCHMENT FOR RAINWATER HARVESTING**  
**LOCATED ABOUT 4.15 Km. FROM DINGARH FORT ON GAPPENWALA TOBA**  
**TRACK, ABOUT 500 METERS EAST OF THE TRACK**

<table>
<thead>
<tr>
<th>Soil Horizon</th>
<th>A1</th>
<th>W1</th>
<th>A2</th>
<th>B2</th>
<th>Cb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soi Depth (Cm)</td>
<td>0-12</td>
<td>12-45</td>
<td>45-75</td>
<td>75-125</td>
<td>125-150</td>
</tr>
<tr>
<td>Texture</td>
<td>Clay loam</td>
<td>Clay loam</td>
<td>Silty clay</td>
<td>Silty clay</td>
<td>Very fine sand</td>
</tr>
<tr>
<td>Structure</td>
<td>Massive</td>
<td>Sub-angular blocky</td>
<td>Sub-angular blocky</td>
<td>Sub-angular blocky</td>
<td>Massive</td>
</tr>
<tr>
<td>Type of pores</td>
<td>Vesicular</td>
<td>Interstitial</td>
<td>Interstitial</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>No. of pores</td>
<td>Common very fine</td>
<td>A few fine</td>
<td>A few very fine</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>pH</td>
<td>9.0</td>
<td>9.0</td>
<td>9.2</td>
<td>9.2</td>
<td>9.2</td>
</tr>
<tr>
<td>Mattes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No. of matles</td>
<td>Nil</td>
<td>A few fine</td>
<td>Common fine</td>
<td>Many fine</td>
<td>A few medium</td>
</tr>
<tr>
<td>Roots</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>No. of roots</td>
<td>Nil</td>
<td>A few fine &amp; medium</td>
<td>A few very fine</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>CaCO3</td>
<td>Common very fine modules</td>
<td>Common fine modules</td>
<td>Common fine modules</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Hardness</td>
<td>Hard</td>
<td>Very hard</td>
<td>Very hard</td>
<td>Very hard</td>
<td>Very friable</td>
</tr>
<tr>
<td>Glyced soil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Buried soil</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**Source:** PADMU - Pakistan Desertiﬁcation Monitoring Unit.

The characteristics of above mentioned profiles show that fine textured soil lies in Cholistan having level to nearly levelled topography is dense, impervious, non porous to very poorly porous, non to very poorly drained, saline-sodic, capable of generating maximum runoff after absorbing minimum water. The features and characteristics of the soil indicate that Cholistan is the best catchment area for rainwater harvesting and collection.

Water intake characteristics of fine textured soils show that infiltration rate is low to very low. It seems due to the absence of pores or due to very poor porosity. However, intake characteristics of soils also prove that the area is suitable for rainwater harvesting and collection.

Rainfall recorded at Dingarh in Cholistan desert, the data shows (table 10, figure 20 a) that sufficient rains are received, which are capable of runoff generation for
rainwater harvesting and collection. About 50 percent rains of the total are thresholds, therefore, maximum water can be collected due to the best features of catchment area for rainwater harvesting.

Table - 10

RAINFALL RECORDED AT DINGARIH
IN CHOLISTAN DESERT

<table>
<thead>
<tr>
<th>Year</th>
<th>Total rainfall (mm)</th>
<th>No. of rains</th>
<th>No. of threshold rains</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>83.0</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>1990</td>
<td>136.1</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>1991</td>
<td>160.0</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>1992</td>
<td>239.4</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>1993</td>
<td>157.0</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>1994</td>
<td>300.0</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>1995</td>
<td>213.0</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>1996</td>
<td>152.0</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: PADMU - Pakistan Desertification Monitoring Unit.

RAINFALL RECORDED AT DINGARIH 1989-1999

![Graph](image)

**FIGURE - 20 a**


3.3 Quality of water

Groundwater in Cholistan is mostly saline. EC (electrolyte conductivity) of sweet water is less than 3 mmho/cm, while the EC of brackish water ranged from 5 to 30 mmho/cm. Low and medium salinity water can be used for irrigation on most of the soils where a certain amount of leaching occurs. Sandy desert areas of
Cholistan may provide excellent strata for quick percolation of water through sand. The salt tolerant plant growing on such sandy soils may be well aerated as sand affords more space between its particles. Chlorides of sodium and magnesium are easily washed down to deeper layers of sandy soils without adversely affecting the selective root system of the plants. Water quality of wells was examined for agricultural use, most of the samples indicate EC (electrolyte conductivity), SAR (sodium adsorption ratio) and RSC (residual sodium carbonate) values beyond the permissible limits allowed for growing crops (table 11, 12).

**Table 11**

GROUND WATER QUALITY OF SOME SELECTED OPEN WELLS IN CHOLISTAN DESERT

<table>
<thead>
<tr>
<th>Location</th>
<th>No. of wells examined</th>
<th>EC_e (dS m⁻¹)</th>
<th>pH</th>
<th>SAR</th>
<th>RSC (meq/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dingarh</td>
<td>6</td>
<td>4.2-8.0</td>
<td>7.2-7.6</td>
<td>14.0-32.0</td>
<td>5.6-14.4</td>
</tr>
<tr>
<td>Hari wala</td>
<td>1</td>
<td>110</td>
<td>7.6</td>
<td>430</td>
<td>8.2</td>
</tr>
<tr>
<td>Kura-khu</td>
<td>1</td>
<td>103</td>
<td>8.3</td>
<td>76.7</td>
<td>13.0</td>
</tr>
<tr>
<td>Bhambo wala</td>
<td>1</td>
<td>12.4</td>
<td>8.0</td>
<td>73.3</td>
<td>11.8</td>
</tr>
<tr>
<td>Baluchori wala</td>
<td>1</td>
<td>22.0</td>
<td>8.3</td>
<td>88.5</td>
<td>10.5</td>
</tr>
<tr>
<td>Channaipur</td>
<td>1</td>
<td>29.8</td>
<td>8.8</td>
<td>207.8</td>
<td>54.0</td>
</tr>
<tr>
<td>Nagar wala</td>
<td>1</td>
<td>7.9</td>
<td>8.5</td>
<td>18.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Marderh</td>
<td>4</td>
<td>3.6-16.5</td>
<td>8.2-8.9</td>
<td>4.4-67.0</td>
<td>12.0-13.4</td>
</tr>
<tr>
<td>Dak wala</td>
<td>1</td>
<td>1.3</td>
<td>8.5</td>
<td>18.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Isbandar</td>
<td>3</td>
<td>2.1-5.0</td>
<td>7.2-7.8</td>
<td>0.9-1.4</td>
<td>0.9-5.8</td>
</tr>
<tr>
<td>Bhakhan wala</td>
<td>5</td>
<td>11.4-26</td>
<td>7.3-7.8</td>
<td>2.0-2.7</td>
<td>5.2-22.0</td>
</tr>
<tr>
<td>Koter wala</td>
<td>2</td>
<td>5.7-5.9</td>
<td>6.5-6.7</td>
<td>1.6-1.7</td>
<td>4.2-4.6</td>
</tr>
<tr>
<td>Chak No 81</td>
<td>1</td>
<td>3.7-8.6</td>
<td>7.0-8.4</td>
<td>21.6-43.4</td>
<td>6.4-13.7</td>
</tr>
<tr>
<td>Malekan wala</td>
<td>1</td>
<td>3.6</td>
<td>7.6</td>
<td>30.9</td>
<td>8.8</td>
</tr>
<tr>
<td>Fort Abbas</td>
<td>1</td>
<td>0.6-2.6</td>
<td>7.7-8.5</td>
<td>3.1-5.2</td>
<td>1.7-6.8</td>
</tr>
</tbody>
</table>

Source: Based on field survey, June 2000.

The electrolyte conductivity of the water samples collected from various places in Cholistan ranged from 0.6 to 29.8 mmho/cm (table 11). The highest concentration of electrolyte conductivity recorded at Channaipur and lowest concentration found at Fort Abbas. Soluble ions (pH) of open wells water samples ranged from 6.5 to 8.9 while RSC (residual sodium carbonate) ranged from 0.9 to 54.0 meq/l. The
The highest concentration of RSC recorded at Chamanpier and lowest at Islamgarh.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Tubewell water</th>
<th>Reservoir water/</th>
<th>Pounded water</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC (dS m⁻¹)</td>
<td>4.90</td>
<td></td>
<td>0.60</td>
</tr>
<tr>
<td>SAR</td>
<td>9.94</td>
<td></td>
<td>3.35</td>
</tr>
<tr>
<td>RSC</td>
<td></td>
<td>6.87</td>
<td></td>
</tr>
<tr>
<td>Na⁺ (meq/l)</td>
<td>25.02</td>
<td>3.16</td>
<td></td>
</tr>
<tr>
<td>Ca²⁺, Mg²⁺ (meq/l)</td>
<td>12.71</td>
<td>2.32</td>
<td></td>
</tr>
<tr>
<td>CO₃²⁻ (meq/l)</td>
<td>0.55</td>
<td>4.55</td>
<td></td>
</tr>
<tr>
<td>HCO₃⁻ (meq/l)</td>
<td>7.42</td>
<td>4.64</td>
<td></td>
</tr>
<tr>
<td>Cl⁻ (meq/l)</td>
<td>27.03</td>
<td>3.60</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Based on field survey, June 2000.

The electrolyte conductivity of water less than 3 mmho/cm is satisfactory for human consumption, whereas livestock can use water of electrolyte conductivity from 10 to 12 mmho/cm. A tentative guide for evaluating the quality of water that can be used by the livestock is given in the table 13.
### Table - 13

#### EVALUATION OF QUALITY OF WATER FOR LIVESTOCK

<table>
<thead>
<tr>
<th>Quality factor</th>
<th>Threshold concentration</th>
<th>Limiting concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>Total dissolved solids (TDS) mg/L</td>
<td>2500</td>
<td>5000**</td>
</tr>
<tr>
<td>Cadmium mg/L</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Calcium mg/L</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>Magnesium mg/L</td>
<td>250</td>
<td>500*</td>
</tr>
<tr>
<td>Sodium mg/L</td>
<td>5000</td>
<td>2000*</td>
</tr>
<tr>
<td>Arsenic mg/L</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Bicarbonate mg/L</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Chloride mg/L</td>
<td>1500</td>
<td>3000</td>
</tr>
<tr>
<td>Fluoride mg/L</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Nitrate mg/L</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Nitrite mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Sulphate mg/L</td>
<td>500</td>
<td>1000*</td>
</tr>
<tr>
<td>Range of pH</td>
<td>6.0 - 8.5</td>
<td>5.6 - 9.0</td>
</tr>
</tbody>
</table>

a) Threshold values represent concentrations at which poultry or sensitive animals might show slight effects from prolonged use of such water. However, such concentrations are of little or no concern.

b) Limiting concentrations are based on interim criteria. Lactating or pregnant animals might show definite adverse reaction.

* Total magnesium compounds plus sodium sulphate should not exceed 50% of the total dissolved solids.

** There are indications that the maximum concentrations of salts that can be tolerated by domestic animals without danger of injury by osmotic effect lies between 15,000 and 17,300 mg/L.

Source: After Khan, 1992.

### 3.3.1 Surface water development for irrigation

Runoff-farming/water harvesting in Cholistan desert can play important role for supply to local people and their livestock for drinking and minor irrigation. It is estimated that if we harvest about 60% of the rainfall, 120 mm per annum from 17% catchment area, 441,900 ha (figure 20 b, table 3), then 0.3 MAF (million acre feet) water can be supplied for drinking and growing vegetables per year. It is observed that at Dingarh, where the soil is clayey, runoff starts after receiving 11 mm rainfall and on sandy soils the runoff starts after receiving about 33 mm rainfall continuously. Pakistan Council of Research in Water Resources (PCRWR)
is collecting runoff at Dingarh by making ditches of different sizes. The harvested water is collected in the pond of size 32.11 m × 32.11 m × 3.67 m = 3783.96 m³.

It is a matter of concern for the environmentalists that Pakistan's precious land resources are subjected to severe land degradation and desertification. Controlling the water lost by evaporative process is one of the most cost-effective methods of maintaining adequate water supplies and should be an integral part of any open top water-storage facility. Although relatively expensive, a roof over the storage is an effective means for controlling evaporation. Floating covers of low-density synthetic foam rubber are effective for controlling evaporation from vertical walled, open topped storages. Evaporation control on ponds or reservoirs with sloping sides is difficult to implement because the water surface area varies as the depth of water changes (Ahmad, 1998b; 1999a).

One of the simpler techniques for utilizing low-cost sheets of plastic or roofing tarpaper is to place a shallow layer of clean gravel on the sheeting after it has been positioned on the catchment surface. The sheeting is the water proofing membrane and the gravel provides protection to the sheeting from wind and sun. This treatment requires a periodic maintenance programme to insure the sheeting remains covered with gravel. Runoff is essentially 100 percent of all precipitation in excess of 2 mm. Windblown dust trapped in the gravel layer is a potential seedbed for plants. The treatment is relatively inexpensive if clean gravel is readily available (Cluff, 1975).

Water harvesting/runoff-farming techniques are technically sound methods of water supply. There have been many water-harvesting/runoff-farming systems constructed and evaluated at many different places in the world. Some of the systems have been outstanding successes, while others were complete failures.
Some of the systems failed, despite extensive effort, because of material and/or design deficiencies. Other systems failed, despite proper material and design, because of social and economic factors that were not adequately integrated into the systems (Frasier, 1983; FAO, 1994). These systems failed because of personnel changes, water was not needed, lack of maintenance and/or because of communication failures. A successful system must be:

- Technically sound, properly designed and maintained,
- Socially acceptable to the water user, and
- Economically feasible in both initial cost and maintenance at the user level.

3.4 Ecological restoration

It is essential that land-based activity, aimed at combating desertification, restoration of ecological balance by utilization of rainwater and improvement in the rural economy by creating stable resource based and increased employment opportunities, decision of participating people becomes paramount to fulfill the needs and interests of individuals and institutions concern. Initiation of such programmes evolved with effective tackling of all inter-related social, economic and environmental issues prevailing in the society that necessitates a comprehensive and relevant policy, administrative and technological framework which promote the programme efficiency by involving local communities in the process of combating desertification and restoring the ecological balance (Ahmad, 1998b; 1999a).

3.5 Strategic Interventions

Local availability of natural resources is declining and increasing demands are being made on the remaining resources, the cumulative impacts on environmental
and social system are being severe. This has resulted in the contentious cross-section of society, as local economic demands of water, grass and fodder expands. Resolution of these conflicts requires new perspective, which combines social, economic and environmental concern with an approach to habitat protection and biodiversity conservation. As a society, we tend to address desertification by using management technology and administrative means while relying on incomplete or inadequate information. In order to monitor this accelerated desertification problem, it is necessary to promote the systematic and successive studies by applying improved rainwater conservation techniques (Ahmad, 1999a).

The ecological balance of nature in this tract is serious upset and is posing a widespread environmental degradation and resource depletion. The only viable scientific solution for recovery and development of resources would be a policy rooted in integrated approach, making sure that the technology deployed is appropriate to local conditions and is conservation oriented.

3.6 Conclusion

The topographic form and the soil characteristics indicate that Cholistan is the best catchment area for rainwater harvesting. Different profiles point out that the area is very poorly drained, capable of generating maximum runoff after absorbing minimum water. Water intake characteristics of fine textured soils show that infiltration rate is low to very low. It seems due to the absence of pores or due to very poor porosity. However, intake characteristics of soils also prove that the area is suitable for rainwater harvesting and collection.
CHAPTER - 4

SOCIO-ECONOMIC DIMENSIONS OF
DESERIFICATION IN CHOLISTAN

4.1 Overview

Cholistan desert is home to over 97,000 (1981) pastoral herders who are part of a larger ethno-linguistic group, the Seraiki speaking people (Government of Pakistan, 1984) have practiced a nomadic life style for centuries. The pastoral system is characterized by mass migrations of animals and people throughout the year in search of water and forage. The onset of monsoon and the distribution of rainfall mainly dictate the pattern of movement of nomadic herders. The incentives for this movement include temporary employment opportunities within the irrigated farming community, grazing of livestock on wheat stubbles, drinking water for human and livestock and readily available markets for livestock and livestock byproducts.

The nomads manage their mixed livestock in such a way that milking cows are moved nearby the urban centres where milk is sold readily while other animals like camels, goats and sheep are kept in the desert for grazing. Nomads attach high values to their herds. Livestock are the main source of their survival and a number of cultural norms are linked with the animals. Livestock are frequently used for meat, milk and gifts. Communal ceremonies like weddings, funerals and tribal celebrations include slaughtering and exchange of animals. A person’s status in the desert nomadic life style is chiefly represented by the size of the herd he owns.
4.2 Social organization

The predominantly Muslim population of Cholistan desert is divided into distinct social groups called qums (marriage among Cholistani Hindu is qum exogamous). Members of each qum differentiate themselves from others by tracing their identity to a common descent. Groups boundaries are maintained by strict adherence to the rule of endogamy which prohibits marriage outside of one's qum. Qums further maintain a sense of unity by sharing resources in moments of scarcity, and by adhering to the rules of reciprocity. Each qum is divided into a number of biradaris, each consisting of a number of three generational matrilineal extended families (Jowkar, 1996). Extended households are formed when sons marry and share a kitchen with their parents.

Each qum has customary leaders, consisting of some respected elders and a formal leader called wadda. Wadda's social and political status is maintained by his ability to respond to people's expectations in arbitrating internal conflict over such issues as terms of warahandi. They are also expected to arrange marriages and make decisions about migration. Although characteristics of intelligence, generosity, hard work and good manners are considered to be more important than wealth, wadda's responsibilities require a measure of economic independence and freedom. Fulfilling such tasks as negotiating conflict with farmers and arbitrating issues with government officers requires an ability to offer high levels of hospitality. Wadda's decisions are not enforced, but a dispute over obeying his words may lead to group fissure.

The other position of authority in the qum is occupied by the numberdar. Based on the Mughal administrative model, numberdari (numberdari system in the old state of Bahawalpur was established in 1869) system was adopted by the British power
to extract taxes and communicate new laws with the local communities (Jowkar, 1996). While wadda represent political identity of extended families within a qum, by resolving intra-family conflicts, numberdari is a position of liaison between the state and each qum, and between herders and farmers. A numberdar’s responsibilities include collecting taxes, registering marriages, and collecting statistics on the number and composition of livestock owned by each household.

In the past, numberdars were selected from locally powerful families, but today they are supposed to be assigned to the position based on character, including intelligence, hard work, trustworthiness, negotiating skills, and leadership. Selected by the local branch of the Forestry Department, a numberdar should be approved by Cholistan Development Authority before taking over his position. Among the nomadic groups, the numberdari position is not hereditary and subject to change should he fall short of fulfilling his duties. For rendering bureaucratic services, numberdars in nomadic areas are compensated with 3 percent of head taxes they collect annually (Jowkar, 1996).

Small qums in Cholistan are represented by one numberdar, but larger qums owning many tobas may be represented by several numberdars, each responsible to link the bureaucracy with a number of herding groups that annually congregate around specific tobas. Because large qums are dispersed over a wide radius, the tasks of collecting taxes and arbitrating conflicts between the nomads, farmers, and the state is divided among a number of numberdars.

4.3 Transhumant

The transhumant system comprises the largest number of immigrating livestock (cattle, sheep and goats) and is characterized by mass movement, including people. Patterns of movement (figure 21) are location specific and dictated by a traditional
MONTH WISE MIGRATORY PATTERNS OF NOMAD PASTORALISTS IN CHOLISTAN

Stay at semi-permanent settlements in the desert

Stay in the irrigated areas.

Stay in the desert at rain-water reservoirs (tobnas)

Weeks of months

FIG. 21

system of land tenure. The timing of irrigation is determined by the onset of the monsoon and rainfall distribution:

- **July/August (monsoon):** Movement is from the irrigated and riverine areas to traditionally owned *tobas* in Lesser or Greater Cholistan. The distances covered vary from 10 to more than 100 Km. Several *tobas* belonging to the same clan may be located within a 1Km radius. At the start of the season, livestock generally graze within a few kilometers of the *toba*; but this distance increases to around 15 Km. by the end of the season.

- **October/November:** As water or forage is depleted at the *tobas*, migration is to semi-permanent settlements having wells and *kunds*.

- **March/April:** Migration is back towards the fringe of the irrigated areas and after wheat harvest, to the Sutlej River for those with traditional, riverine rights. Irrigation canals are the water sources, but feed supplies are differentiated according to two sub-systems:
  - Pastoral sub-system herds are partly fed on dried forage, on vegetation along canal banks, roadsides, and partly on purchased fodder. Some stubble is available after the wheat harvest in May;
  - Agro-pastoral systems herds are partly fed on dried forage but depend heavily on fodder crops and residues since their owners possess irrigated land.

The transhumant system, being heavily dependent on the timing and quantity of rainfall, can be severely disrupted by drought. For example, during a prolonged drought over the last 4 to 6 years preceding this study, most of the herders barely moved south, some staying only a few days or for a few months before being compelled to return.

Average herd sizes in the pastoral system were small with a total of 106 sheep units consisting mainly of sheep (46%), cattle (34%) and goats (20%). In the agro-
pastoral system disparity in herd sizes was variable, but the average herd size was much larger at 779 sheep units, with cattle, sheep and camels predominant.

Several constraints to productivity are identified by the socio-economic study in the transhumant system, all of these being linked to water supply and its balance with forage and fodder:

- The general constraint is inadequacy of water in the desert. This was compounded by the recent drought when tobas became silted in the absence of herders. Some 25 out of 43 tobas (June 2000) seen in Greater Cholistan were filled with sediment.

- In the eastern, arid region, toba water is of good quality but limited so that feed is still available when thirsty herds are forced to migrate. On the other hand, in the semi-permanent settlements, well water is adequate but of poor, saline quality. The wells are unlined and most to be re-dug each year because the surrounding sand collapses.

- In the western hyper-arid region on the other hand, the quantities of both water and feed are inadequate. Feed is frequently depleted first so the sheep, whose walking range for pasture is confined to within 3 or 4 Km. of water, must be moved ahead of the rest of the animals to other tobas or to wells. All herds are kept for as long as possible in the well areas, or on the Sutlej floodplain. Many of the wells have brackish water which, together with the prolonged period of food shortage, results in poor body condition.

- A major constraint for all landless pastoralists is the scarcity of free grazing during their sojourn on the irrigated fringe or the floodplain even though fresh water is abundant.

4.4 Nomadic system

The nomadic system applies to the larger herds of camels and goats which remain throughout the year in the desert of Lesser or Greater Cholistan. The size of such camel herds is from around 4 to 150, and the goat's herds are of variable sizes.
Depending on the size of the herds to be left in the desert, one or two members of each household will remain behind to tend the herds. In addition, a herdsman will be hired to assist if the herd is particularly large. The other members of the household will follow the normal transhumant system and will return to the irrigated land, taking along one or two camels for transport. Households with only a few surplus camels, less than 5, for their transport needs will leave these behind to be cared for the arrangement with the owners of the larger herds. During winter and summer these nomadic animals drink from wells at the semi-permanent settlements. During the monsoon and post monsoon they drink from tabas like all the order animals. Natural grazing is the exclusive nutritional source for the nomadic animals living permanently in the desert (Jowkar, 1996).

The major constrains to the nomadic system are very poor quality of drinking water and inadequate feed, both of which are acute during summer. *Haloxylon salicornicum*, an evergreen shrub, provides most of the feed from late winter to summer. Animals must travel long distances of up to 15 Km. to search for their feed, which, in any event, is insufficient. Furthermore, well water salinity increases to very high levels over summer, especially in the western part. The combination of long distance travel, harsh temperature rising to 50°C or more, undernourishment and highly saline water all contribute to a reported high mortality rate.

### 4.5 Nomadic-sedentary conflict

A major threat to nomadic livestock husbandry in Cholistan is the alienation of rangelands for agriculture. While it would be wrong to claim that the past was an age of perfect harmony among different users of scarce resources, access to land and water was formerly regulated through local codes of tradition and diplomacy, and a nomadic group could be reasonably assured of adequate supplies of each
during its semiannual transhumance between summer and winter grazing lands. Today, however, access to resources varies with social position in the status hierarchy of the area, and in this picture Cholistan herders are increasingly shortchanged.

Incidents of conflict, especially those over trespassing livestock, are arbitrated by the numberdars. If their arbitration proves to be ineffective, the case is taken to the local police, who according to both farmers and herders extort money from both sides before finally taking the side of the party who pays a higher bribe.

Despite rampant incidents of conflict, farmers and herders provide each other valuable services. Postharvest residues of cotton and wheat are exchanged for livestock dropping on the fields, which fertilize the land and enhance its productivity. Local institutions reinforce this mutual dependency by providing contractual frameworks that reduce confrontation. Based on experience and trust, each year farmers and herders' pair up, and nomadic livestock browse on a rotational basis on segments of the farm land fenced and separated from the rest. This rotational arrangement (war a ale) assures that benefits accrue to both sides, while reducing the likelihood of conflict. Farmers monitor the animals to prevent trespassing onto fenced portions of their lands during the day, but herders are held responsible for any such incidents happening overnight. Fertilization may be exchanged for wheat straw during the dry season, when postharvest residues are finished and fields are prepared for the next crop. Herders without relatives may even be offered food by farmers' families.

4.6 Colonization of Cholistan

The first colonization of the Cholistan Desert for large-scale irrigation dates to the early 1940s under the Sutlej Valley Project (CDA, 1996), when Cholistan was part
of Bahawalpur State, ruled by the Nawabs. Under the first official round of land allocation, about 5,758 acres of land was allocated in 50-acre parcels. The next round distributed 31,041 acres in 12.5-acre allotments. Inspite of dubious returns from irrigation, the offer of land attracted a large number of Punjabis to the area, because under these two schemes land allocation was irrespective of ethnicity (Jowkar, 1996). Cholistanis initially disdained the sessile life-style associated with farming, only a few applied for lease deeds, thereby setting the basis for their future subordinate status in the region’s ethnic hierarchy.

In 1970, a third scheme allocated 25,475 acres in 12.5-acre parcels. Because this time only Cholistanis could apply, Punjabis complained for discrimination by the government. Proof of Cholistani identity, the only criterion to qualify for allotments, included records of grazing fee paid to the Revenue Office by the herders. It is estimated that about 6,500 Cholistani households qualified. Those who did not qualify were all granted parcels of 12.5 acres regardless of their family size, it resulted that in the next generation there was not enough land to support the heirs or the holdings were divided into very small segments (CDA, 1996).

As irrigated agriculture expanded on former grazing lands, and the settler population grew rapidly, market towns mushroomed in the area, providing services for their residents and the nearby populations. Existing towns like Bahawalpur and Yazman became important centres for settler activity (Bakhsh, 1993). Supported by strong systems of biradari linking them with the Punjabi-dominated bureaucracy, the settlers occupy high status in the local power hierarchy.

After Bhutto’s Land Reform and the deposing of the Nawabs from their stately positions, land distribution continued. In 1976, an estimated 22,375 acres of land, formerly belonging to the Nawab’s family, was distributed (CDA, 1996). Although
under the land reform law, a new ceiling was set, allowing affluent farmers to accumulate very large holdings. Large landlords sometime controlled holdings that were in fact registered in the names of illiterate peasant, often without latter's knowledge.

During the last scheme, substantial additional acreage was allocated, and an increasing number of Cholistanis requested such land, whose value had clearly raised and generated considerable income for the owners. Under this scheme any landless individual could apply, but in response to Cholistani protest about prior discrimination, they were given first priority in the new distribution.

In 1983, the year that the last parcels were distributed, Cholistan Development Authority (CDA), the agency in charge of land allocation, shifted its development policy from allocating allotments to providing social services such as roads, water resources, and like. Despite official discontinuation of allotments, CDA still accepts applications, and herders continued to hope to become holders of tenancies.

4.7 Gender division of labour and poverty

As in other pastoral societies, the most striking Cholistani social relationship has to do with the division of labour and control over poverty. Unlike pastoral lands, whose access is through 'rights of the user' vested in the community by the state, management of livestock involves such smaller social units as the household. Men, women, and children, with different rights and obligations, contribute to the day-to-day reproductive needs of the herd. Within each livestock management unit, rights over animals are differentiated by sex and age, with older men generally privileged in the ownership and disposal of animals through sale and slaughter.
Men’s *de jure* ownership rights over animals are guaranteed by a gender-discriminatory set of inheritance rules that reinforce men’s economic dominance.

In Cholistan herding communities, although the family herd is divided among different sons, animals usually remain in the same herd belonging to the extended family. Extended households, comprised of a man, his unmarried children, his married son, and their wives and children, graze their livestock as part of one herd. Division of family livestock into different herds may take place years after sons marry. Decisions about sons’ inheritance depend on the father’s discretion, both in terms of timing of division of the family herd and number of livestock allocated (although local evaluations of the appropriateness of behaviour may well constrain fathers who might otherwise be “overly” generous or “overly” covetous). While some families divide the herd equally among the sons, others may favour their youngest sons, especially, if they are not yet married – a decision to compensate for the money spent for the wedding of the older sons. Although sons may decide at some point to establish separate households, it is common for brothers to continue herding their livestock together. Newly married couples may have their own separate dwellings, but they share meals with the groom’s family.

In Cholistan women do not inherit livestock. Yet, these discriminatory inheritance laws favouring men’s greater control over livestock do not imply women’s total exclusion from animal ownership. Young women (Horowitz, 1992), depending on the financial status and generosity of their families, receive a dowry at the time of their weddings. Women also receive jewelry from their husband’s family. A woman’s *de jure* rights over these animals and their offspring may, however, be violated by her husband, who may sell or slaughter her animals. Depending on her will and family support, she may argue against the sale of the livestock, but not always with success.
In addition to the dowry, the bride's family also donates a few animals to the bridegroom during the ceremony of *salami*, when he visits his father-in-laws to express his respect. A shared property of both husband and wife, the animals and their offspring would return to the bride's family were divorce a possibility. But because cousin marriage is preferred, *salami* gifts remain in the extended family herd.

Men's contribution to the pastoral economy concentrates in grazing, watering, migration, and milking responsibilities. In Greater Cholistan, male labour input in grazing is minimal, because the cattle are night grazers and need little supervision. Small ruminants, however, need more attention, because they are vulnerable to attacks from jackals. Male labour contribution is crucial during migration and around agricultural fields, when they must closely watch their animals to keep them from intruding on cultivated fields and damaging the crops. Hauling and watering animals during the dry months, a labour intensive task, is also exclusively a male duty. In the dry season men either have to haul water from wells or follow their herds to canals and river banks away from their settlements. During the months, when herds are taken away in search of water and forage, women, children and older people remain in the proximity of settlements, caring for the newly born livestock. Primarily men also do milking, except in their absence or during the monsoons when greater milk production demands women's contribution. Men's labour load is particularly high in the dry months, because of labour intensive tasks of hauling water and keeping constant vigil on their herds for fear of trespassing.

Young boys' contribution to herding and transhumance is particularly important. Little boys as young as five years may accompany shepherds in their daily routines, learning livestock related skills.
Women's contribution in livestock related tasks vary seasonally. For example, although mostly men do milking, women's participation in milking is particularly important during the monsoon months when production is at its peak. Women state that the monsoon season is the busiest time of the year, when in addition to their routine work, they have to milk animals and process large quantities of dairy. During this time, although the night-grazing Cholistani cattle venture into the desert unattended, small ruminants with shorter grazing range are attended by shepherds, some of whom may be women.

In Cholistan, as in many Muslim pastoral societies, where adherence to the code of honour and shame restricts contact between unrelated sexes, women's independent mobility away from the home site is constrained and regulated. However, gender values are negotiable, especially when either labour or cash short. Although pastoral women rarely leave their camps even for shopping for jewelry and clothing, they often take daily trips to distant places to collect firewood for domestic consumption. During the dry months, they fetch water for domestic use, a task that takes them away from settlements to far distant wells and kmds. Often walking in small groups, women carry up to three gourds on their heads. Married women continue to carry water from wells until their unmarried daughters are old enough to assume the responsibility.

Where nomadic households are not close to sources of drinking water, water is hauled in large bags on camelback from distant points. If male members of the family are not available, a young woman performs the task by riding a camel to water points every morning, carrying back large bags of water for cooking and drinking. The water carried in such bags, hanging on both sides of a camel, is divided among related households and conserved in gourds away from the reach of animals in order to maintain sanitation.
Men’s greater responsibility in herding and migration is complemented by women’s large role in domestic duties. In addition to childcare, washing, carrying water, dairying, and cooking, women also distribute food in their households and larger communities. Women’s domestic tasks may be carried out individually or collectively.

During the dry months when the milk output is slim, poor households suffer great nutritional stress. Short of milk animals, women, especially from poor families, may exchange their labour and services for milk donations from wealthier women who are over burdened with their daily chores. Similarly, poor men may be hired as shepherds by labour-short, wealthier households with large herds and allotments.

While weaving in many pastoral communities is women’s responsibility, for Cholistani pastoralists weaving does not constitute an important activity, neither for domestic consumption nor for market production. Cholistani women mat, flasies, are produced by poor families - the jolahas - who because of poverty have adopted weaving. Some jolahas travel along with pastoral communities and some live near allotments, where they weave for herders from wool, which has been given to them.

The integration of pastoralism into the market economy has increased cash dependency. In addition to livestock sales, seasonal wage labour on agricultural fields provides an avenue for generating income. While men from poor families are drawn to small industries and agriculture, women mainly work as seasonal labourers on cotton and wheat fields. Cotton harvesting, an exclusively female activity, draws women from both farming and herding communities. During the harvest, between November and January, thousands of women travel in groups to
cotton fields: some returning to their homes every night and some staying on the fields for the duration of the harvest. Each year women find their work through word-of-mouth, but some may return to the same farms each year depending on a shared feeling of trust.

Although daily wages are customarily one sixteenth of what is picked, they are subject to fluctuation in the market price of cotton. Sometimes employers may buy the pickers' share of their cotton with the hope that they can sell it later at a higher price. Wages may also be paid in cash, a daily payment of about Rs. 40-50. With their wages, cotton pickers buy jewelry, cloth and necessities for their children.

Harvesting of cotton is an exclusively female activity, but wheat harvesting attracts whole families, including children, to the fields. Wages are paid in kind or cash. Pickers use their payment in kind, 40 Kg. per acre of wheat picked, for their domestic consumption. Cash payment is used to obtain such necessities as cloth, medicine and grain.

4.8 Natural grazing

Livestock production in Greater Cholistan is dependent on access to grazing in Lesser Cholistan because conditions during summer in Greater Cholistan are most unsuitable for livestock, excluding camels and because irrigation water for drinking and fodder are available in Lesser Cholistan when they are very scarce in Greater Cholistan during spring and the pre-monsoon.

The broad picture of land use is that pastoralists move into Greater Cholistan in about August. This is after the monsoon rains when adequate pastures are available for livestock, when water in tobas has been re-supplied by surface runoff, and when temperature is bearable. The pastoralists then follow a nomadic lifestyle,
moving from one toba to the next as water and pastures become exhausted. Around December they fall back, generally in a westerly direction, to wells and kunds, some of which may be in Lesser Cholistan. By March they will have completed the westward retreat into Lesser Cholistan where the majority will stay on the fringe of the irrigated area. Their livestock will take advantage of whatever growth is available, whether on the dry lands or along irrigation canals and from stubble which is available at no cost. Additional fodder is purchased from the irrigated lands.

Apart from camels, some goats and a few herders, Greater Cholistan is thus vacated from March to August because of unbearable temperature, known to reach 51°C and the lack of water and pastures, which prevail until conditions are changed by the monsoon.

Livestock production and human life in Greater Cholistan would be almost impossible without access to adjacent, better-watered land during the driest and hottest season as is made available in Lesser Cholistan. On the other hand, Lesser Cholistan has limited free grazing and fodder purchase is expensive. Pastoralists thus prefer to keep their animals for a minimal period in Lesser Cholistan.

Large quantities of the shrub Calligonum polygonoides and Haloxylon salicornicum were seen during field survey in January 1999. In some cases, whole butts were uprooted. The areas around habitations are the worst affected, and a significant proportion of the natural grazing in Lesser Cholistan is being converted into wasteland. In contrast, almost all of the irrigated lands remains in a highly productive and stable condition.
4.9 Traditional grazing system

The traditional grazers, organized into families and clans, have more common understandings about their respective rights to particular grazing lands and watering points including tobas and wells. The main feature that is interesting is that each clan moves about within its territory and makes nomadic use of each area until feed or water supplies, or both, are exhausted. In some cases, particularly where permanent wells are available to a clan, a dry season feed reserve is kept until last. Thereafter, nearly all clan are forced to move towards the irrigated lands until rainfall in Greater Cholistan allows their return.

Whatever the clan movements or social structure, their present management system appears to make little deliberate provision for conservation of the health of the pastures by resting or other methods. The consequences have been:

- a reduction in the abundance of palatable species, especially grasses;
- overall severe loss of vegetation cover in areas surrounding habitations and tobas within a radius of 1 Km, with gradual improvement further away;
- poor conditions in cattle, for those pastoralists who do not own irrigated or other land, or who are denied access to the irrigated fringe during the pre-monsoon; and
- reduced habitat opportunities for wildlife.

4.10 Carrying capacity

The following considerations of stocking rate, grazing capacity and supporting capacity reveals that the rangelands are not overstocked as a whole in Cholistan.
The stocking rate is described as the area of the grazing land available to an individual animal. It is expressed in hectares/sheep unit of 35 Kg. Based on the 1997-98 livestock population and using a documented conservation factor, the total number of nomadic/transhumant sheep units in Cholistan are 706,349. Assuming uniform distribution, the gross stocking rate is calculated as:

\[
\begin{align*}
\text{Effective area of grazing lands} &= 1,819,791 \text{ ha} \\
\text{No. of nomadic/transhumant animals} &= 706,349 \text{ sheep units} \\
\text{Gross stocking rate} &= 2.6 \text{ ha/sheep unit}
\end{align*}
\]

The reduction in availability of free pasture is of concern to pastoralists. Some expressed a desire for land rights or other recognized tenure of the non-arable parts of Lesser Cholistan; whilst nearly everyone not already in possession of an irrigable plot (5 ha) seeks one. Ownership of irrigated land provides a secure and presumably, inalienable title to the land, the possibilities for fodder production and cash cropping as well as water for livestock. Those pastoralists not in possession of the irrigable land must pay high prices for fodder during the dry season. Poor Cholistanis with only a few livestock must sell their labour to the farmers in order to survive.

4.11 Livestock numbers

Some difficulty was experienced in obtaining current estimates of livestock numbers and discrepancies existed between figures (table 14) quoted by different state agencies. The following estimates were taken from: (a) The Livestock Services Department, Bahawalpur gave figures for 1997/98; (b) from The Department of Forestry Census for 1997/98; (c) an extrapolation of numbers obtained from numberers during socio-economic study, which is regarded as the
most reliable data. There is an estimated 706,349 sheep units in Cholistan; equivalent to a stocking rate of 2.6 ha/sheep unit in the rangelands.

Table - 14

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>307,000</td>
<td>73,048</td>
<td>244,600</td>
</tr>
<tr>
<td>Buffalo</td>
<td>3,170</td>
<td>not given</td>
<td>3,200</td>
</tr>
<tr>
<td>Sheep</td>
<td>383,000</td>
<td>147,429</td>
<td>448,600</td>
</tr>
<tr>
<td>Goats</td>
<td>798,000</td>
<td>53,680</td>
<td>162,400</td>
</tr>
<tr>
<td>Camels</td>
<td>15,600</td>
<td>16,510</td>
<td>93,300</td>
</tr>
<tr>
<td>Total</td>
<td>1,526,770</td>
<td>290,667</td>
<td>952,100</td>
</tr>
</tbody>
</table>

Source: Based on field survey, January 1999.

The socio-economic study gives some information on the monetary value of the livestock. The Forestry Department has given its estimates of earnings of animals by-products generated from their judgement of 0.3 to 0.4 million livestock in the rangelands.

- Wool: Rs. 5 million
- Hides: Rs. 0.4 million
- Bones: Rs. 0.1 to 0.2 million
- Milk, butter, ghee: Rs. 5 million

4.11.1 Water demands of livestock species

Water demand by desert livestock varies with the species as is evident from the table below:

<table>
<thead>
<tr>
<th>Species</th>
<th>Consumption/day/animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep and goats</td>
<td>4 liters</td>
</tr>
<tr>
<td>Cattle</td>
<td>20 liters</td>
</tr>
<tr>
<td>Camels</td>
<td>10 liters</td>
</tr>
</tbody>
</table>

Source: Based on field survey, January 1999.
4.11.2 Water frequency

The average watering frequencies during normal desert environment is given below:

<table>
<thead>
<tr>
<th>Species</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep and goats</td>
<td>3 – 4 days</td>
</tr>
<tr>
<td>Cattle</td>
<td>2 – 3 days</td>
</tr>
<tr>
<td>Camels</td>
<td>10–14 days</td>
</tr>
</tbody>
</table>

Source: Based on field survey, January 1999.

4.12 Actual drinking water requirement

The demand for water can be determined from the actual number of people, livestock species and the specific needs per day. An amount of 10 percent is added for waste caused by the animals and the watering people. For instance, the actual water needs per day of Cholistan, based on the 1981 census, have been calculated in the table 15. This does not include water needs of the wildlife in the region.

Table – 15

<table>
<thead>
<tr>
<th>Species</th>
<th>Number</th>
<th>Water (m³)</th>
<th>Wastage (10 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>People</td>
<td>97,000</td>
<td>969.43</td>
<td>96.94</td>
</tr>
<tr>
<td>Sheep/goats</td>
<td>1,027,880</td>
<td>4,109.09</td>
<td>410.91</td>
</tr>
<tr>
<td>Cattle</td>
<td>163,283</td>
<td>3,263.67</td>
<td>326.37</td>
</tr>
<tr>
<td>Camels</td>
<td>21,000</td>
<td>209.87</td>
<td>20.99</td>
</tr>
<tr>
<td>Total</td>
<td>1,300,160</td>
<td>8,552.06</td>
<td>855.23</td>
</tr>
</tbody>
</table>

Source: After Khan, 1992.

Mean livestock densities per sq. Km multiplied by the water needs per day of each of the livestock species, multiplied by 100 will give actual water need per 100 sq. Km per day. Possible variable standard deviation should also be taken into
account. By this method map of the actual water needs of Cholistan ranges be prepared for use in its future water resources development plan (Khan, 1992).

4.12.1 Domestic water use

The use of water by the people is directly related to the distance from the well. The farther the water has to be carried, the less the people will use it. Usually water for domestic use is drawn every third day, ideally from water points which are not more than 15 Km. away. Longer distances create tremendous hardships and are only feasible if the household has 2-4 pack camels. However, where the water point is in the vicinity of the settlement water may be drawn every day.

<table>
<thead>
<tr>
<th>Distance to water source</th>
<th>Consumption/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 Km</td>
<td>2-3 Liters</td>
</tr>
<tr>
<td>1 Km</td>
<td>3-6 Liters</td>
</tr>
<tr>
<td>Next to house</td>
<td>10-20 Liters</td>
</tr>
</tbody>
</table>

The mean consumption per person per day is assumed to be 10 liters.

Source: Based on field survey, January 1999.

4.13 Conclusion

Pastoral nomadism is not only an environmentally sustainable way of managing the Cholistan drylands, but it could extend support to national dairy and meat consumption requirements. The likelihood of an increase in the number of livestock, by making feed supplement more accessible and affordable in the dry seasons, could be reduced by increasing offtake through marketing of animals for urban consumption. Support for the livestock sector will automatically increase herders’ income and increased offtake through marketing, reduces the likelihood of overgrazing. It reveals that sustainable use of resources with the promotion of indigenous technology will benefit the local people.
CHAPTER - 5

NATIONAL AND INTERNATIONAL AWARENESS:
GRASSROOTS INITIATIVES

5.1 Debate on desertification

Desertification is an environmental problem that has major ecological – physical and social dimensions (Thomas, 1997), which has been contributing in number of ways. Desertification has been high on the agenda of global environmental agenda since 1970s, though the term was first conceived by Aubreville in 1949.

Desertification has been the subject of much activity and research in the physical sciences. Since long scientists are attempting to define desertification on scientifically rigorous criteria, activity has tended to focus on four broad areas. First, there have been attempts to assess, as reliably as possible, the extent and nature of the problem and the rate at which it might be increasing or diminishing. This has occurred at the global level (UN, 1977; UNEP, 1992; Thomas, 1997), at the national or regional level (Hanan et al, 1991) and in relation to other specific research projects, for example, are concerned with a particular land use type or process that may contribute to desertification (Abel & Stocking, 1987; Hellden, 1991 and Thomas, 1997).

Second, there has been research that has attempted to identify the physical processes of desertification with a view to understand how systems subject to degrading disturbances actually function and change. Examples include research on the physical dimensions of salinization (Rhoades, 1990) and that which has been investigating the nature of rangeland degradation in terms of vegetation (Scoones, 1989) and soil system changes (Thomas, 1997). Third, there are
researches that aim at identifying appropriate remedial actions to stabilize or recover lands subject to desertification (Brown & Woll, 1986; Roose, 1988). Fourth, there has been important researches conducted into the relationship between desertification and other environmental problems and natural hazards that occur in drylands (Walker & Rowntree, 1977; Hulme, 1989), including recent explorations of the positions of desertification in the context of predicted anthropogenically-induced global climate changes (Williams & Balling, 1995).

Despite the activity within the physical sciences, desertification, with its social impacts and human causes, is also an issue in the domain of social sciences. The human dimension of desertification is of marked importance given that ultimately any solution to the problem requires attitude and decision-making changes on the part of local land users and communities (Blaikie, 1989).

More than one hundred definitions have been recorded by the various scholars (Glantz and Orlovsky, 1987; Warren and Agnew, 1988; Odingo, 1990). Desertification is defined by UNCED (United Nations Conference on Environment and Development) in Agenda 21 as “Land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities”. Land and degradation are defined as: “Land in this concept includes soil and local water resources, land surface and vegetation or crops and degradation implies reduction of resources potential by one or a combination of processes acting on the land”. These processes include water erosion, wind erosion and sedimentation by those agents, long term reduction in the amount or diversity of natural vegetation, where relevant, and salinization and sodication (UNEP, 1992).

Some definitions include both climatic and human causes, others restrict it to human-caused degradation; some restrict the term to the drylands, while others link
it to more humid areas as well. The question of ‘irreversibility’ has been included by some, with all the controversy that this term invokes. More recently, debate has begun about the validity of using vegetation degradation as an indicator of desertification.

The UN stressed that desertification is not something that emerged from deserts, carried by the hot, dry winds. It can occur anywhere where land is overexploited, and it is generally not correct to envisage it as an advancing wall of sand dunes or desert frontier. Rather, it is usually ‘...far removed from any nebulous front line’ and it ‘...is a more subtle and insidious process’ than the advancing desert front (United Nations, 1978; Stiles, 1995).

FAO/UNEP (1983) offered a revised definition of desertification in the context of their efforts to develop a methodology for assessing and mapping desertification:

Desertification is defined as a comprehensive expression of economic and social processes as well as those natural or induced ones, which destroy the equilibrium of soil, vegetation, air and water, in the areas subject to edaphic and/or climatic aridity. Continued deterioration leads to a decrease in, or destruction of, the biological potential of the land, deterioration of living conditions and an increase of desert landscape.

Although this definition included aridity in it, but again does not define its boundaries. However, FAO maps of desertification always excluded areas with more than a 180 days’ agricultural growing period. It also introduced the concept of ecological equilibrium, one that is now under reevaluation in dryland grazing ecosystems. FAO/UNEP also viewed desertification as a process, going through several stages before reaching the final irreversible one. The processes are both natural and human, but desertification could only be slowed or stopped by human actions (Stiles, 1995).

Dregne (1983), a long-standing expert in desertification, offered the definition:
Desertification is the improvement of terrestrial ecosystems under the impact of man. It is the process of deterioration in these ecosystems that can be measured by reduced productivity of desirable plants, undesirable alterations in the biomass and the diversity of the micro and macro fauna and flora, accelerated soil deterioration, and increased hazards for human occupancy.

Dregne’s definition is one of the few that do not mention climatic factors in the causation. The definition is also not restricted to drylands, but Dregne states that he goes along with the general view that it should be. By using such terms as ‘desirable’ and ‘undesirable’ he also introduces the concept of a socio-economic rather than purely biological assessment of land degradation. An undesirable alteration in biomass could be bush encroachment into rangelands, decreasing their economic value for grazing livestock. In purely biological terms, however, bush would have raised productivity.

Nelson (1988) strongly criticized the entire concept of desertification as one that was poorly characterized and as a term that ‘obscures its true shape’ because of the diversity of definitions. This did not prevent him from adding to that diversity by offering his own definition:

Desertification is a process of sustained land (soil and vegetation) degradation in arid, semi-arid and dry sub-humid areas, caused at least partly by man. It reduces productive potential to an extent, which can neither be readily reversed by removing the cause nor easily reclaimed without substantial investment.

Nelson goes along with FAO in defining the upper limit of drylands as having no more than a 180-days growing season and a maximum of 1200 mm average rainfall. He recognized that degradation was naturally reversible and that fluctuations occurred, so he introduced the concept of relative irreversibility. Thus, he arbitrarily defined as a 10-year natural recovery period of productive potential, or a substantial capital investment to effect rehabilitation. Presumably, if natural recovery would take more than 10-years, or if the investment is uneconomical, then one could say that desertification is occurring.
FAO (1993) has more recently added biodiversity to its definition:

Desertification is the sum of geological, climatic, biological and human factors, which lead to the degradation of the physical, chemical and biological potential of lands in arid and semi-arid areas, and endangers biodiversity and survival of human communities.

Warren and Agnew (1988) do not offer a definition of desertification of their own, but concluded after a review of definitions: ‘The definitions do not distinguish between desertification and processes that diminish rather than eliminate productivity without necessarily producing deserts, namely land degradation’. They take ‘desertification’ in a very literal sense. They argue that sparser vegetation, i.e. lower biological productivity, can sometimes be more nutritive and desirable for livestock than more biologically productive vegetation, thus productivity itself is not a valid indicator. They think that desertification must cause permanent degradation and that vegetation resiliency means that vegetation degradation must be very serious to be an indicator of desertification.

These, and other, criticisms that were promoting the UN to reconsider the official definition of desertification. An Ad Hoc Consultative Meeting of experts convened in 1990 decided that there is no point in distinguishing desertification from land degradation in the drylands, as this only confused the whole problem. What is of primary concern is the fact that land is degrading and producing less food and commercial output, resulting in increased hardship, poverty and migration. Whether land actually ended up looking like a desert is immaterial and not of relevance to the socio-economic questions and these technical squabbles are diverting attention from the real issues of concern. The final definition adopted by the AD Hoc group is (UNEP, 1991):

Desertification/land degradation, in the context of assessment, is land degradation in arid, semi-arid and dry sub-humid areas resulting from adverse human impact. Land in this concept includes soil and local water resources, land surface and
vegetation and crops. Degradation implies reduction of resource potential by one or a combination of processes acting on the land. These processes include water erosion, wind erosion and sedimentation by those agents. Long-term reduction in the amount or diversity of natural vegetation, where relevant, and salinization and sodication.

UNCED added climatic variations to human impacts as contributing causes in definition. The final UNCED definition approved by *Agenda 21* reads: 'desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities' (UNEP, 1992).

Drylands are defined by an adaptation of the Thornthwaite Moisture Index of the ratio of precipitation to potential evapotranspiration (UNEP, 1991):

<table>
<thead>
<tr>
<th>Type</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyper-arid</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Arid</td>
<td>0.05-0.20</td>
</tr>
<tr>
<td>Semi-arid</td>
<td>0.21-0.50</td>
</tr>
<tr>
<td>Dry sub-humid</td>
<td>0.51-0.65</td>
</tr>
<tr>
<td>Moist sub-humid</td>
<td>&gt;0.65</td>
</tr>
</tbody>
</table>

Hyper-arid areas are considered to be unproductive land, except in very small pockets of favourability and are therefore not included in measurements of desertification. In spite of the fact that the international community formally accepted at UNCED the recommendation of a group of dryland experts to include vegetation as an important indicator of land degradation, some still do not accept the new definition and wish to distinguish desertification from land degradation as something unique (Thomas and Middleton, 1994).

Thomas and Middleton (1994) have taken the views expressed by Warren and Agnew (1988), these two works contain a number of incorrect statements of fact and misinterpretation (Stiles, 1994; 1995).
Desertification is best seen as land degradation taking place in the drylands as defined above, the principles and processes as those seen in other eco-climatic zones. It is a cluster of processes, which can fluctuate, with periods of regeneration, and it is only irreversible economically in its mid to later stages. Its nature and causes will be particular to any given situation, depending on the natural ecosystem variable and history of land use. It is normally a very slow process, and thus can be assessed only over decades of observation, not years. It is rarely ecologically irreversible, though natural regeneration would only occur from a severe state either in the absence of human pressure or under exceptionally good management practices. It is nothing mysterious and singular, and the term is more of a political symbol than a scientific expression (Stiles, 1995).

5.2 Negotiation of the Convention

During 47th session in 1992, the United Nations General Assembly, as requested by United Nations Conference on Environment and Development (UNCED), adopted resolution 47/188 calling for the establishment of the INCD. At the time organizational session of the INCD in January 1993, delegates elected Bo Kjellen (Sweden) Chair of the Committee. The INCD met five times between May 1993 and June 1994, during which delegates drafted the Convention and four regional annexure. The Convention was adopted on the closing day of INCD-5 in Paris, along with resolutions recommending urgent action for Africa and interim arrangement for the period between adoption of the CCD and its entry into force on December 26, 1996.

5.3 A brief history of the INCD

Convention to Combat Desertification (CCD) is one of the main environmental instruments initiated at the historic occasion of UNCED or Earth Summit held at Rio de Janeiro on 3 - 14 June 1992 in Brazil. UN constituted INCD
(Intergovernmental-negotiating committee to elaborate a Convention to Combat Desertification in those countries experiencing serious drought and/or desertification, particularly in Africa). The Convention was adopted on 17 June 1994 and opened for signature in Paris on 14 and 15 October 1994. The Convention entered into force on 26 December 1996. It is an operational convention, which takes an innovative approach in the way it tackles desertification and international environmental law as a whole. It is designed to forge a new government, the international community, development practitioners and local people. The convention (UNEP, 1994) contains 40 articles and four regional annexure (on the implementation of the treaty in Africa, Asia, Latin America and Caribbean and the Northern Mediterranean) its regularly repeated aim is to combat desertification and mitigate the effects of drought.

5.4 Brief debate on a convention

Governments negotiate conventions. They are aimed at gaining common agreement amongst countries about how to deal with a common problem. They usually involve each country giving up some of their own power in order to achieve something considered of greater importance for the world community as a whole. Thus, conventions contain a number of commitments, or promises, which governments make about how they will behave in future. They agree to report on the actions, to ensure that every party to the agreement actually carries out their promises. This reporting is done to the ‘Conference of the parties’, which is made up of representatives from all governments which have signed and ratified the convention (Toulmin, 1995).

Once the text of a convention has been agreed, governments must then choose whether or not they want to sign and ratify it. At the signing ceremony for the Desertification Convention in October 1994, 86 countries actually signed the
Convention and a further 19 governments have now done so. But this does not mean that the Convention is ready to operate. The text of the Convention notes that at least fifty countries must ratify the convention before it becomes legally binding. ‘Ratifying’ a convention involves each government passing this agreement through its own legal system at national level. This usually means the Convention must be discussed in the parliament or national assembly and members of the assembly agree to the commitments enshrined within the Convention text. After achievement of fifty ratifications, the Convention to Combat Desertification has become fully operational in 1996 (Stiles, 1994; Toulmin, 1995).

5.5 Fundamental principles

The Convention pioneers a democratic, bottom-up approach in international environmental law. It emphasizes that the people who bear the brunt of desertification must be fully involved and be allowed to participate in the decisions that will shape their lives.

The first principle of the treaty is struggle against desertification, in collaboration with local government, state functionaries, scientific institutions and NGOs, pastoral groups, farmer organizations, agricultural labourers, rangeland managers, women groups, youth and private sectors.

The second principle again breaks new ground by stressing the need for international partnership and co-ordination, both to avoid duplication and partnership, improve co-operation and co-ordination at national, regional and international levels.

The third principle of the treaty extends the concept of partnership to relationship within the effected countries so, re-emphasizes the importance of ensuring the participation of local people and countries.
The Convention is the starting point for a new approach to the problem of desertification. At the same time, it is plainly the outcome of many efforts that have helped raise stakeholders' awareness, build a store of experience and prove that it is indeed possible to halt remedy the degradation of ecosystems in arid, semi-arid and dry sub-humid areas. It was those efforts and the limits that led the international community to recognize the need of a collective commitment to meet the challenge of desertification: the commitment that materialized in the convention.

More than one third of the earth's landmass and estimated 70% of the part used for farming is already degraded. In Africa, slightly over one billion hectares – that is, more than 73% of the continent's drylands – are moderately or seriously affected by desertification. In Asia, the phenomenon extends over 1.4 billion hectares. North America is the continent where the proportion of dryland affected by desertification is the highest in the world; 74%. Overall, more than 110 countries have drylands that are more or less degraded. The phenomenon affects the means of subsistence of more than a billion individuals, one fifth of world population.

If no strategy to combat desertification is adopted, the risks are considerable. The rural population will continue to grow until crop yield reaches their marginal utility value. In other words, until the soil has been depleted to the extent that it cannot return even the seed put into it. Even before reaching this point, the local population will probably have no choice but to abandon its territory and move either to new lands (as long as a "frontier" is available) or, more likely, to big cities, unless a precarious balance is struck between emigrant workers and the families that stay at the desertified land (UNEP, 1996). Land abandoned by farmers will probably be taken over by livestock herders, but with overgrazing added to soil degradation, the process of depletion will be repeated a little further.
down the line. In degraded and desertified areas, new balances will be established, but at much lower levels of biomass productivity. The net result of the biosphere will be large negative, due to diminished hydrological exchange, increased albedo and a decrease in carbon sequestration. Equally serious effects will ensure for food security, as deficits from desertified areas combine with the global shortfalls that FAO puts at very close range. From the demographic standpoint, the urban population is projected to grow with a concentration in huge, polluted, ill-served mega-cities and increasing poverty.

The fight against desertification takes place in spatial units larger than the scale of the individual, or of the family farm. The balance and imbalance of dryland ecosystems generate interactions that occur on very large scales and it is only on such scales that we can measure the outcome of an effort to combat desertification. But by a kind of paradox, local populations do not perceive the "ecological" space as an ensemble, by the people who use its resources.

The space in which the fight against desertification is waged should thus be considered as an ensemble of "primary local spaces" and they are the places to start when seeking to identify interlocutors capable of acting on the ecosystem. The "challenge of space" is thus the challenge of an action that can be undertaken only by starting from a significant number of "local spaces" and can succeed only by virtue of millions of decisions taken by their users (UNEP, 1996).

The time dimension is itself dual. On the one hand, it relates to the speed of natural resource degradation, to the irreversibility that will inevitably ensue from the various pressures on resources; when will it actually begin to be "too late"? The time dimension is also what measures the biological length of the source restoration process; will it not take some twenty years, for example, or at least a very long time, to lasting revegetize a degraded area?
A long term "vision" of what "sustainable" balance might be cannot mask these realities. It cannot avoid relating human needs to the development potential of natural environment threatened by desertification. Considering current production levels what, for example, is the "carrying capacity" of a village's land? In other words, how many families can it support, yielding their subsistence plus a small surplus for trade? And what would its capacity be one or two decades hence if the population has become half again or two times larger? What role would horizontal expansion play, or an input of better technology? These kinds of questions bring up the issue some times known as the "production possibility frontier" (UNEP, 1996). Awareness of the existence of limits to the carrying capacity of land is essential, even if science can measure them only in parts. Local populations must know that in most cases, all the efforts they undertake to restore their environment will at best enable only some of the them to survive these way; there will be no place for the others. In fact, no scenario can be envisaged without sweeping changes in the ratios between rural population and urban population and without unprecedented large population shifts.

The ecological challenge posed by combating desertification thus appears in its most complex dimension: on the one hand, it is an effort to change ways of managing nature, but on the other hand it is an overall effort to promote development, control migratory flows, devise new urbanization policies that encourage the growth of rural villages and midsize towns, diversified economic activities, created jobs and raise incomes. There is no other way to reducing the pressure of poverty on natural resources (UNEP, 1996).

Combating desertification is necessarily a multidimensional process; it cannot be reduced to its technical aspects, but must also take account of the other facets of the problem. It is thus a comprehensive, all-out effort. The establishment of a
connection between poverty and the process of desertification and environmental degradation – at the Earth Summit in Rio de Janeiro (1992), at the Copenhagen Conference on Social Development (1994) and at the Brussels Conference on Hunger and Poverty (1995) – seems to have been decisive in this respect; there now exists a very wide consensus for a comprehensive, integrated approach. The Convention itself makes this approach a cardinal element in the policies it advocates.

The Convention notes that there already exists a wealth of experience in this area, but that is far from sufficient where the goal is, for example, to minimize costs of optimizing the combating of long-term effects and near to medium-term results.

Convention to Combat Desertification embodies the will of the entire international community to act in concert, and over a long period of time, to address a problem that directly or indirectly affects the whole planet. Some countries are concerned more directly, because of the local effects of aridity and of desertification process on the natural resources that mainly sustain their population. But the problem does not spare the other country, for they are just as concerned, though more indirectly, by the effects of desertification on the balance of the global ecosystem and by the repercussion on the world economy and on international aid policies generated by the spreading of desertification-related pockets of poverty. Poor countries that are not affected by the problem of aridity and desertification (according to the criteria established in the text of the Convention) may nonetheless be equally interested in its implementation, for its provision and approaches can in large part be transposed to the specific problem that those countries will face in improving the management of their renewable natural resources, preserving their forests and restoring fertility of their soils.
The Convention is the legal instrument (UNEP, 1996; IFAD, 1998) binding upon the parties, which engage to take the steps and commit the resources necessary to implement the approaches described in its provisions. Its uniqueness, compared with earlier approaches to better resource management in the countries affected by desertification (approaches that up to now have relied on medium term programmes or projects decides in a centralized and technocratic way on a case-by-case basis), lies in measures taken to act in a very long term perspective and to encourage participation, at all levels, by the actors most directly affected. In the regard, the Convention represents a departure from the top-down policies that have prevailed for so long, for it processes to ground the fight against desertification on a principle of partnership and solidarity uniting donors, government, local administrations and the populations directly affected (UNEP, 1996). The Convention is also unique in its provision for harmonizing mechanism in the framework within which various parties decide to define and plan strategies to combat desertification and its causes. To this end, the Convention recommends improving the coordination and application of foreign assistance and a consensus seems to have been reached on defining aid requirements according to jointly accepted long term strategic goals and on achieving greater continuity and better allocation of the resources mobilized for this purpose.

The Convention makes ample provision for the need to disseminate technical information, improve knowledge, conduct research and transfer as they are in national action programmes. Scientific monitoring of the desertification is most appropriate to record the views and the perception of the local farmers. United Nations Convention to Combat Desertification also stresses the involvement of the grass-roots people, the real stakeholders in the planning of National Action Programme for Controlling Desertification.
Debate on National Action Programme

The fundamental objective of a National Action Programme (NAP) is to help local people and organizations to improve dryland resource management and deal with the effects of drought. It should thus outline how the government plans to achieve this and the roles to be played by different people and organizations. NAPs are intended to be much more than a one-off planning document. The Convention clearly recognizes that governments have only a limited role to play and that they cannot hope to intervene themselves in many areas (Toulmin, 1995). The role of government is seen as establishing a general setting, which encourages ordinary people and organizations to do things themselves. This means people must feel confident of the benefits, which they will gain from the activities, they carry out.

The preparation of National Action Programmes (NAPs) is the focal point of the Convention. NGOs have an important role to play ensuring that the people affected by dryland degradation have become involved in deciding the activities to be carried out (Toulmin, 1995). The Parties shall:

Encourage NGOs to support the elaboration, implementation and follow-up of action programmes (Article 9.3); seek the expertise of NGOs in the collection, analysis, exchange and dissemination of relevant information (Article 16d).

The Convention clearly signifies the importance of participatory mechanism to launch NAP to combat desertification. In this situation National Coordination Committee to Combat Desertification (NCCD), represented by all stakeholders will be the principal forum to take on the assignment of setting up parameters of NAP and its implementation process in future, as shown in the Convention text:

Promote policies and strengthen institutional frameworks which develop cooperation and coordination, in a spirit of partnership, between the donor community, governments at all levels, local populations, and community groups, and facilitate access by local populations to appropriate information and technology (Article 10.2c, SECTION ONE PART III) ...provide for effective
participation at the local, national and regional levels of non-governmental organizations and local populations, both women and men, particularly resource users, including framers and pastoralists and their representative organizations, in policy planning, decision-making, and implementation and review of national action programmes (Article 10.2f – SECTION ONE, PART III) . . . designate appropriate bodies responsible for the preparation, coordination and implementation of their action programmes (Article 4-1a - ASIAN ANNEX) . . . involve affected populations, including local communities, in the elaboration, coordination and implementation of their action programmes through a locally driven consultative process, with the cooperation of local authorities and relevant national and non-governmental organizations (Article 4-1b – ASIAN ANNEX).

The NAP involves two phases; namely, the preparatory phase and the implementation phase. Since preparatory phase is apprehended to be the foundation stone for all proposed development activities, it asks for talking all essential cares so that a pragmatic NAP may be formulated. The dynamics of a workable NAP must be fixed by keeping a number of essential elements and mechanism in view, which are as:

5.7 Elements of an Ideal National Action Programme

The NAP will provide a framework for examining existing policies and programmes to address economic, social and institutional issues, which may in the past have prevented the adoption of appropriate management practices.

The lack of uniformity, the diversity of vegetation, soil and climatic types, each with its own set of constraints and opportunities for ecologically sustained use, will ensure that NAP is:

- Broadly based and flexible,
- Identifies common issues,
- Encourages a coordinated and integrated approach to improved land use and desertification control,
- It should be participatory, which revolves around participation of stakeholders at all levels, including the scientific institution, private sector, government, local government, NGOs, farmers, pastoralists, women, youth etc;
• The National Action Programme should be integrated with other environment, development and planning processes, so as to avoid duplication (UNEP; ESCAP and PARC, 1996).

It is not envisaged that a consensus will be reached on all of the issues relevant to land use. It will be necessary to highlight areas where differences of opinion occur, as part of identifying where progress could be made with more appropriate management, policies or programmes that may exist.

Land management is a broad issue and NAP should recognize the interrelated nature of economic (development and adjustment); environmental and social issues and facilitate the integration of conservation and production-oriented management. The strategy should provide a vision, which has meaning, it tangible for land managers and policy makers at the local and regional levels and is action-oriented towards meeting specified objectives.

The first step is to draw out the issues considered be important to the various stakeholders. It will not be possible to get all the issues in the first round of discussions, others will emerge over time, but this set will act as a further discussion and refinement of ideas as part of development the National Action Programme.

The series of issues will provide the first opportunity for those with an interest and involvement in land use and desertification control in Pakistan to have input into development of the NAP.

5.8 Issues in desertification control:

5.8.1 Involvement of stakeholders

The various stakeholders are likely to have different views on issues affecting land use and land management, on possible solution. The NAP should take this into
account and suggest mechanisms to improve resolution of conflicts that could arise. An effective NAP will require a willing and coordinated approach by all stakeholders for many years into the future. The NAP is not an end point but the start of a long journey towards solving problems of desertification in Pakistan.

5.8.1.1 Infrastructure

While different group of users of Pakistan’s fragile ecosystems may have varied requirements relating to their specific use of land, as a community they have similar problems and interests. Both the lack of, and often-poorer quality of, infrastructure and services underpin many of these common problems and interests. Communication and transport infrastructure is a particular interest. In many areas, telecommunications are only just beginning to reach the standard of urban dwellers. These issues contribute to greater isolation of rural communities.

Awareness and access to the broader range of government services and programmes in an issue for most rural Pakistanis. Services such as schooling, particularly for secondary and post-secondary education; health services, particularly for patients who require emergency or specialized care; and programmes to assist the unemployed. The NAP should take into account the isolation of rural communities, in the context of equity of provision of services and social justice as well as the cost of providing these services.

5.8.1.2 Planning, management and tools

Any activity undertaken in a particular area should be related to the overall (or agreed) management objectives of the area. Regional planning based on objectives and appropriate ecological boundaries, which take into account the ecological diversity as well as the range of uses of that particular area, could be a useful approach.
Land managers include Federal and regional government agencies, farmers, pastoralists and peasant associations, tourism interests and conservation agencies (Squires, 1998). Often these different land managers focus on different goals. Some of the information issues affecting management, which could be explored further, includes:

- Level of relevant information available about Pakistan's land and water resources and the management regimes in place,
- Identification of information gaps and the extent to which these gaps constrain ecologically sustainable development and exacerbate desertification,
- Condition of various landscapes in Pakistan, their sensitivity and vulnerability to desertification,
- Establishment of a system to obtain information, which is, appropriate, accessible and useable by land users and managers to combat desertification.

5.8.1.2a Tools (Policy, legislation, education/extension)

Federal and regional government, tertiary institutions and research agencies have all made contribution to improved management of Pakistan's fragile ecosystems. Governments have used a number of measures, with varying degrees of success to influence the manager in which land is used and managed, for example:

- Employment of extension officer to provide information and advice in relation to land management and control of land degradation. Techniques and practices that sustain productivity have been demonstrated. There is now increasing reliance upon development in communication (radio, TV) and education to more efficiency disseminate new ideas and approaches to land managers and users,
- Various financial incentives to encourage sustainable land management,
- Land use regulations, which can be effective tools, but have sometimes led to inappropriate management practices and/or outcomes.
5.8.1.3 Land tenure

The NAP should consider whether existing land tenure and the management regimes they encourage, is appropriate and effective in achieving the outcomes desired. Some issues to be considered are:

- Flexibility of tenure arrangements and the effects of tenure arrangements on the objective of ecologically sustainable development as outlined in the National Conservation Strategy (Government of Pakistan and IUCN, 1992),
- Security and rights of tenure arrangements and implications for the environment, people and communities,
- Involvement and accountability of governments in encouraging ecologically sustainable and management, alternatives and multiple land use.

5.8.2 Ecological sustainability issues

Country relies on activities that use land-based biological resources to maintain and enhance their standard of living. The economic use of these lands contributes significantly to regional employment but it has been now raised that there are elements of the development and use of the natural resources which have not been ecologically sustainable as evidenced by loss of biodiversity, extensive land degradation and problems with water and forestry resources.

Decisions determining the use of the land should be based on an assessment of the environmental, social and economic benefits, the cost of proposed options, efficient, equitable and transparent. Consideration should be given, how these values might be conserved, perhaps through government regulations.

5.8.2.1 Economic viability of current land use

Over recent decades the rural sector has experienced a deteriorating economic situation which may regard as the worst ever faced. The declining economic situation in the rural sector raises some important issues:
• As rural producers slide further into poverty, land management is further compromised and greater environmental degradation results. Pressure for more government action to alleviate the situation becomes less productive.

• It is generally not cost-effective to rehabilitate severely degraded land. Preventing degradation or allowing natural factors to rehabilitate less severely degraded land, by increasing fallow times on cropland or lowering stocking rates in pastoral land, for example, may be cost-effective methods to address degradation.

5.8.3 Land degradation

Desertification is defined as land degradation caused by climatic and human factors. It is a major issue and one of the most complex to consider objectively. Degradation means different things to different people and it is inappropriate to consider land simply as either degraded or not degraded. Human intervention has long been a factor in the evolution of Pakistan’s landscapes and views are divided on the extent of change and whether this constitutes desertification. Some would argue that recent human intervention has changed the condition of the land from what it was as recently as two or three decades ago. Severe degradation has undoubtedly occurred as evidenced by the lack of productivity.

Degradation is an ecological issue occurring when ecological processes or characteristics are changed and the integrity of the ecosystem is threatened or lost. It is related to changes in the land and vegetation and hydrologic regime which makes it less capable of meeting its desired uses and results from the interaction between vegetation and soil type (Squires, 1989; 1998), hydrology, climatic variability and land use pressures.

These are various degrees of degradation (for example, land is good productive condition, land degraded out recoverable, land uneconomically recoverable) and various types of degradation such as loss of soil, or biodiversity loss. The degree and type of degradation and the region in which it occurs should all be taken into
account in making assessment or comments on degradation. In developing the NAP, it may also be important to develop a better understanding of the various views of the degradation and perceptions of desertification.

5.8.4 Social issues (Structural adjustment)

Structural adjustment should be considered from a community-wide perspective, as effects on individuals and the wider communities are closely related. The current need for structural adjustment in most of the desertified regions of Pakistan has resulted from a combination of environmental, economic, social and institutional factors. These have included:

- The natural climatic variability,
- Increased costs of inputs,
- Higher costs of providing infrastructure and services to rural communities,
- Declining prices for commodities on world markers,
- Lack of knowledge of environmental impacts of various land uses.

Government policies, which have encouraged inappropriate settlement patterns, set constraints on property size or recognized agriculture, have also contributed to structural problems for many users and communities.

The NAP should examine opportunities to facilitate structural adjustment in rural areas. Issues such as education, alternative income sources, employment opportunities, improved risk and financial management need to be explored to enhance the sustainability of Pakistan’s landscape and communities they support. The strategy also needs to recognize that some communities are in decline and that some land is now unproductive for agriculture. But many areas of Pakistan are particularly significant in terms of their history and culture. They may be some
prospect to develop alternatives land uses or forms of income generating activities associated with these.

5.8.5 Information system

Land managers, regardless of land use, require information on the impact that various types of management have on environmental and economic parameters. Whilst some land managers have gained considerable information through experience, there is a need to define the information requirements for all levels of rangeland users. Information on environmental and economic performance is, at best, patchy and it is difficult to build up a satisfactory picture across all areas from the information currently available. Not only is the information necessary for land users to facilitate suitable management, but also for land administration and policy makers to allow development of policies and programmes appropriate to ecologically sustainable development (Squires, 1998).

The NAP should develop guidelines to meet the different monitoring and information requirements of the various users group, consistent with the guidelines in previous strategies such as National Conservation Strategy (1992).

5.8.6 Monitoring

Monitoring systems are designed to gather more information on changes in the condition of land, but the question raises what, how and by whom should be monitored? Consideration should be given to the purposes of monitoring and issues such as intensity of monitoring, the balance between collection of sufficient, detailed, meaningful data and the cost of monitoring. Monitoring should be sufficiently holistic to give a basic perspective, rather than focusing too closely on one element, be it related to economics or environment.
Monitoring and assessment should be scientifically and economically based and allow adequate scrutiny of the techniques used and the conclusions made, particularly where the information is used when making decisions on future land use. Data should be compatible in terms of methodology and objectives, so that valid comparisons can be made between information collected by different agencies and findings can be extrapolated.

5.8.7 Institutional issues (Government policy measures)

The development of the NAP has potential to significantly alter government's approaches to land management. The NAP will need to recognize the extent to which Federal, regional and local governments are already undertaking activities, which encourage ecologically sustainable develop and arrest existing degradation. It should examine the mix of exiting policy measures and look a develop a policy package, which leads to the desired strategy objectives. A review of some programmes may be appropriate to ensure consistency with the overall goals and objectives of land management in desertified lands.

5.9 Mechanism for building a National Action Programme

The suggested steps for formulation of NAP are as follows:

- Countries should have clear vision and political commitment before initiating the NAP,
- Establishment of a facilitating working group under the relevant Convention to Combat Desertification (CCD) local point ministry, or department of the government, which should be preferably include an NGO for the implementation of CCD,
- Identification of all major stakeholders organization,
- Drawing up of terms of references and the agenda of the national forum of stakeholders,
- Organization of a national forum which would lead to establish NCCD,
• Official recognition, legitimization and utilization to NCCD by the Government,
• Draft recommendations by the NCCD to develop NAP,
• Identification of key players to work on NAP and to ensure their full participation,
• Allocation of assignment to the key players/actors,
• Synchronization and integration of the NAP with policy and planning process in the country, as well as, with already under implementation, bilateral and national programmes(s) of land degradation and environmentally sound development,
• Liaison with the donors and their involvement from the beginning of the process,
• Holding of national wide consultation on NAP at all levels,
• Preparation of first draft of NAP and wide circulation of the draft among the stakeholders,
• Analysis of the feedback received from the relevant sources and incorporating the suggestion(s),
• Finalization of the NAP (UNEP; ESCAP and PARC, 1996).

5.10 Implementation phase

After the preparation of NAP, its implementation also requires some sophisticated and apt action to be outlined by NCCD under the following components:

• Implementation of catalyst urgent actions,
• Setting up of adequate financing mechanism,
• To integrate programmes/projects relating to the elimination of poverty, conserving biodiversity etc;
• Implement priority programmes,
• Monitoring of the on-going activities by developing anti-desertification indicators/indices so that the effectiveness of the programme is assessed,
• Propagating the success stories of the NAP programme from different parts of the country where the CCD programme is being implemented (UNEP; ESCAP and PARC, 1996).

The Ministry of Food and Agriculture is responsible for preparation and implementation of National Action Programme for arid land development and combating desertification. The work of NAP started in 1993, after a national level consultation. The programme covers six agro-ecological zones of Pakistan and identifies major problems, which cause desertification. These include salinization and sodicity of soil, mismanagement of rangelands, overgrazing deforestation in the catchment areas and mismanagement in the irrigation system on the part of Government departments and farmers themselves. NAP suggests wide scale prevention and rehabilitation work to halt desertification. These initiatives include irrigation efficiency at farm level, early completion and effective working of drainage infrastructure, massive afforestation in the water shed and catchment areas, introduction of salt resisting plant species, soil holding grasses and massive plantation of arid land bushes with oil rich seeds. The programme is supposed to be implemented by an integrating institutional mechanism, which includes a Combating Desertification Authority, which will work at federal and provincial level with different ministries and departments like, forestry, irrigation, agriculture, etc. The NGOs are given an important position in National Action Programme, as they are identified as the vehicles for implementation of this National Action Programme (figure 22).

As a whole the NGOs in the integration of people groups in the NAP is of primary importance. For this purpose an NGO supposed to be of national repute, having sufficient capacity of communication, management, convincing and playing an honest intermediary role among Government, donors and local organizations. Such NGO must be a part of larger networks of NGOs and relevant institutions and must
ARIDLAND DEVELOPMENT/COMBATING DESERTIFICATION IN PAKISTAN

POLICY & PLANNING

ARIDLAND DEVELOPMENT COMMISSIONER MINFAL

RESEARCH TRAINING

FAO/UNDP

JICA/BILATERAL

UNEP/ESCAP

WB/ADB

ICARDA/ICRAF

ECO/SAARC/OIC

ICIMOD/IUCN

MIN. FAL

PLANN. COMM.

MIN. ENVIR

MIN. S&T

MIN. W&P

PARC

PFER

PCRWR

NIAB & AZRI

VAF/BARANI UNI.

NWFP AGRI. UNI.

UBWF & KUKHL.

MINA P&D ARID DEV. CELL

SINDH P&D ARID DEV. CELL

NWFP P&D ARID DEV. CELL

BALOUCH P&D ARID DEV. CELL

NA P&D ARID DEV. CELL

ABAD/CTDA

SAZIDA

FOREST DEPT.

FOREST DEPT.

FOREST DEPT.

FOREST DEPT.

AGRI DEPT.

AGRI DEPT.

AGRI DEPT.

AGRI DEPT.

EPA

EPA

EPA

EPA

NRSP/NGOS

SCOPE/NGOS

Existing

Proposed

(Figure 22) Proposed Institutional Strategy for Aridland Development/Combating Desertification in Pakistan.

SOURCE: Pakistan Agricultural Research Council. 1993
have access to the information about the updated trends and a happening in the world regarding the implementation of the CCD is concerned. The NGO must possess organizational capacity of handling consultation process.

Experts and professionals in the field of agriculture, rangeland management and irrigation prepared NAP in Pakistan. However, this programme does not reflect the opinions or real stakeholders such as farmers, pastoralists (Ahmad, 1997a; 1998a), local authorities, women and community volunteers. This is a serious set back in the NAP designing which will defuse the implementation of NAP in the long run because the whole programme, will end up into huge bureaucratic structures, office equipments, laboratories, large number of field vehicles. This programme will be financed by heavy bank loans and credits, which will be paid back by the poor people and taxpayers ultimately. The success of implementation no doubt depends on the participation of stakeholders as the NAP itself mentions it, and such effective participation is only ensured when the community groups should also be consulted for preparation of NAP.

5.11 Role of local bodies in implementation of CCD

UN Convention to Combat Desertification, in many ways is a break through the status up quo. By drawing up and signing this convention more than 100 governments have made specific and solid commitments towards ensuring viable economic resources, friendly environment and sustainable living to proceed coming generation. Among many other things it involves local people in finding their own solution to the issue relating desertification and land degradation. The Convention to Combat Desertification was adopted on June 17, 1994 and opened for signatures in October that year (I.c,i,n. 1995). Containing 40 articles and four regional annexure, out of those more than 8 articles are directly addressing to the local bodies (UNEP, 1994). The convention has already become effective and has
entered into implementation stage after the 50th ratification, took place on December 26, 1996.

Accompanied by political commitment and will, the Convention could represent a single internationally negotiated vehicle for bringing tangible benefits to the 900 million predominantly poor and food-insecure people who live in the dryland areas that cover 30% of the planet (Ahmad, 1997).

Past approaches to resources conservation that excluded resource users failed because they: generated active local opposition; ignored the need of tangible incentives to farmers; and degenerated to an absence of management rather than the expected state management of dryland resources (Megateli et al, 1997).

5.12 Main features of CCD

The most important feature of (CCD) is that unlike some other international conventions it includes concrete national commitments for practical actions, particularly at the local level where desertification must primarily be fought and place a great emphasis on the machinery needed to implement it and monitor its progress.

The Convention pioneers a democratic, bottom-up approach in international environmental law. It clearly emphasizes that the people who are facing desertification, best understand the fragile environments in which they live must be fully involved and be allowed to participate in the decisions that will shape their lives. The first principle of the treaty commits parties to ensure that decisions on the design and implementation of programme...are to be taken with the participation of populations and local communities and that enabling environment is created at higher levels to facilitate action at national and local level.
CCD is different from previous attempts to combat the crisis and ensure sustainable development because it legally binds the countries to obliged and implement the Convention in its true spirit and words. Unlike other international environmental treaties, it includes concrete national commitments for practical action, particularly at the local level where desertification must primarily be fought and places great emphasis on the machinery needed to implement it and monitor its progress.

As rightly suggested by Wollers (1996) the efforts of the affected countries will focus on supporting a process by which the level of education and living standards can be raised and traditional systems, locally controlled as far as possible, adapted to the current situation, in order to delay the process of desertification and reduce its effects. Let us consider above all the approach to local measures to combat desertification since in each case specific and appropriate solutions must be developed on the spot.

In a developing country like Pakistan, in developing and applying desertification control measures, consideration must be given not only to the appropriate technical measures but also to economic and social factors, together with all traditional customs of the local population. Any measures to protect resources will be successful only if it is supported and carried out by the local people. Consequently, the motivation of the target groups to support desertification control measures must be based on measurable economic success, which result in financial gain.

5.13 Role of local Government

In the past, development planners too often tended to ignore the people inspite of the fact that the poor communities know more than anyone else about the fragile ecosystem with which they have been endeavoring throughout their lives. They should be the keys to combat the desertification. The Convention acknowledges
this and recognizes that development must be human-orientated if it is to be sustainable. It breaks new ground and embraces a “bottom-up” approach, insisting that local people must be fully involved in deciding how to tackle the problem of desertification and that their poverty should be addressed.

The third principle of the Convention extends the concept of partnership. It emphasizes the importance of ensuring the participation of local people and their communities. It stresses upon the need that national plans must be carried out in a spirit of partnership, between the donor community, government at all levels, local population and community groups.

The institutions of Local Government assume a dynamic responsibility towards the development and maintenance of local resources, find out local initiatives and motivate the civil society towards a desirable change because:

- Representatives of the local population who are given definite mandate by the communities of their areas and are run on democratic principles govern them,
- Governors of local Governments have committed for the betterment of socio-economic and environmental conditions in their areas,
- Institutions of local Government work within the limited areas of having face to face relations with the local population and stakeholders,
- They are intermediaries between local population and the national Government and hence may guide the national planners by feeding them with the local initiatives, their essential needs, wishes and hopes,
- Institutions of local Government have normally built an infrastructure and capacity to undertake development activities,
- They represent both national Government and local population in favour to bringing a change in the attitude and behaviour of the stakeholders of beneficiaries (Kazmi, 2000).

They may be the factors that can be attributed towards giving emphasis of the local Government in the UN Convention to Combat Desertification by mentioning them

5.13.1 Expected participation of local bodies

One of the most important elements of the Convention to Combat Desertification is formation of National Action Programme (NAP) by signatories, which is actually linked-up with the implementation of this Convention.

In practice NAP is to be drawn up by a democratic process, which will require the participation of all actors (stakeholders). Since National Action Programmes are the backbone of the implementation mechanisms of CCD. It is desirable that the local communities (figure 23) must be considered throughout all the development processes involving formulation, implementation and monitoring stages of plans consulted both at drafting and implementation stages. Although in Pakistan first draft (April 1994) and second draft (December 1996) of NAP are completed, yet no significant contribution of local communities was sought for these drafts. Nevertheless, a limited NGO participation was noticed in the first draft, which is a negligible representation of the Civil Society. It is desirable that a local participation of the indigenous and civil society is essentially needed for a dynamic and feasible NAP. This must be taken into account before the final approval of the NAP.
IMPLEMENTATION MECHANISM OF NATIONAL ACTION PROGRAMME

Government

Concerned Ministries

NARC
PARC/PCRWR
University Dept.
PFI
NIAB

Research Institute

NCCD

INT’L COLLAB.

Province

FAO
UNDP/UNEP
ESCAP
WB/ADB/JICA
ICIMOD/IUCN

PCCD

DFPs (District)

Forest Department

Agricultural Department

EPA

Representative of DFPs

DFPs (District)

Local Bodies
CBOs/NGOs

NCCD: National Coordination Committee to Combat Desertification,
PCCD: Provincial Coordination Committee to Combat Desertification,
DFPs: District Focal Points.
CBOs/NGOs: Community Based Organizations/ Non-Governmental Organizations.


Figure 23
5.13.2 Role of District Councils/Union Councils

District Councils and Union Councils can play an effective role in the implementation of the CCD in Pakistan. This is because of the fact that Union Councils and District Councils have sufficient mechanism and infrastructure to implement and monitor the CCD activities. Furthermore, they could also develop the infrastructure and raise funds to combat land degradation in their respective areas. Similarly, these councils can also be used as platforms for the capacity building and training of the NGOs, CBOs and VOs in the affected areas (Kazmi, 2000).

In addition to that these can also be treated as forums of accountability. As Convention gives full-authority to local bodies to criticize the implementation mechanism of the CCD at any stage. The institutions of local Government can play a significant role in:

- Disseminating people’s perception to planners of provincial and federal governments,
- Helping in formulation of dynamic plan for sustainable development,
- Helping local communities for harnessing benefits from development activities and enhance their income,
- Providing essential infrastructure demanded for undertaking desirable development,
- Extending meaningful evaluation and monitoring measures for development projects and feedback to planners,
- Create awareness building in civil society,
- Ensures accountability at various stages of the projects,
- Acquiring desired volume of funds from different agencies.
5.14 Conclusion

For successful implementation of CCD in Pakistan, a very strong local involvement is needed to achieve the expected results. Therefore, it is recommended that Government of Pakistan must create a policy for participatory development based on local materials and techniques within the framework of existing indigenous and public property institutions. Community based management system, which is an essential pre-condition to effective resource management could be blended with traditional tribal structures so that there is a consensus of the community, or the clan, that they will collectively support actions.

District Councils and Union Councils can play an effective role in the implementation of the CCD in Pakistan. This is because of the fact that they have sufficient mechanism and infrastructure to implement and monitor the CCD activities. District Councils and Union Councils can also be used as platforms for the capacity building and training of the NGOs, CBOs and VOs in the affected areas.
CHAPTER – 6

IMPACT OF DESERTIFICATION

Local perceptions are derived from the experiences of observable change over time and serve as the basis for a “grassroots indicator”. The differences in this way local people and intellectuals conceptualize issues based on “cause and effect” reasoning which has been characteristics of antidesertification studies (Kazmi, 1997b). CCD (1994) strongly recommends the need for the community consultation and to record the views and traditional strategies to control desertification. Therefore, in this chapter I would like to analyze the spatial pattern of perception that are being noticed during field survey.

6.1 Overview

Environment represents a multidimensional system of complex interrelationships subjected to a continuous state of change. It is this kind of an environment, including physical, biotic and man-made features, which we live amidst. Perception refers to both phenomenal experience as well as a directive for action. Accepting the position taken by Kittelson, a noted psychologist, the modern version of the concept of perception relates to the whole perception-cognitive system, which involves complex judgements, rather than simple sensory discriminations. Such apparent features subtly influence such judgements as the individual's value hierarchy (Kittelson, 1973; Zaidi, 1975; 1976). Environmental perception depicts a subjective interpretation and valuation of the environment by environed individual. It is subjective because our description and understanding of the environment are communicated through the filters of personal experience, learning, imagination and fantasy, memory, myths and iconography (Lowenthal, 1961; Zaidi, 1972; 1976).
Personal interests motivate our own differentiation among places, people and things. We deal rather with reality as perceived. In other words, we are still parochial in our attitude and behaviour. Even in this modern age when the earth surface has greatly shrunk and our world is supposed to have been explored completely, “the world horizon is accepted in theory but rejected in practice” (Whittlesey, 1945; Zaidi, 1976).

The theory of environmental perception takes good care of the questions related to the assessment of environmental quality and the intensity of parochial feelings, the two most burning problems of modern world, which are of direct relevance to our task of developing purposeful principles for organizing the administrative areas so as to be able to maximize the chances that the plan is accepted by the inhabitants willingly, and that at the same time the chances of conflicts are minimized (Zaidi, 1976; 1984; 1985). Methodologically, the theme of environmental perception provides us with a conceptual framework rooted in an ecological perspective termed as "cognitive behaviourism" (Saarinen, 1966; Zaidi, 1976; 1997).

6.2 Local population

Cholistan desert is home to over 97,000 (1981) pastoral herders who are part of a larger ethno-linguistic group, the Seraiki speaking people (Government of Pakistan, 1984). As the original inhabitants of the Indus Valley Civilization, the Seraiki, with long linguistic, cultural, and political ties with ‘Sindhis’, developed their own distinct national identity, represented by the independent state of Bahawalpur under the Nawabs’ rule until 1947. Mostly of nomadic origin, some Seraiki were settled under the Nawab, known as Riasati, this group’s ethnic identity is rooted in their historic and linguistic distinction and linkage to Cholistan desert (Jowkar, 1996). Muslim/Hindu plurality and ethnic tolerance, a prominent feature of the pre partition era, has been replaced by ethnic discord and
disenfranchisement of Seraiki, in particular the nomadic pastoralists of Cholistan (Horowitz et al., 1995).

Today of the estimated 97,000 (1981) inhabitants of Cholistan desert only a small minority of Hindus remain. These Hindus belong to the Maighwal and Rawal tribes groups. The Muslim populations are organized in clans, of which the most important are Sama, Laar, Sheikh, Bohar, Charhua, Diha, Bhatti, Panwar, Joo'ya, and Langa. In addition to these indigenous groups, some Pathan and Baluch groups also migrated into the area generations ago (Jowkar, 1995; IDA, 1996).

6.3 Social hierarchy

With the influx of Punjabis into the area and recent economic development, the indigenous population, particularly the pastoralists of Cholistan desert, has become increasingly disprivileged. Among the recent changes, the allocation of allotments has particularly affected the internal structure of the Cholistani pastoral society. In the past, economic differentiation was the mainly determined by the number of livestock owned. The economically powerful qums (marriage among Cholistani Hindu is qum exogamous) – e.g., Sheikh and Kalvar – had large populations with many livestock (Jowkar, 1996). They also had claim over many tobas that could accommodate their large herds every summer. Their superior position was reaffirmed by their generosity in allowing other qums to use their tobas if needed. Likewise, within each qum, large extended households with easy access to a labour pool could accumulate large herds. Men and women contributed to various livestock-related tasks, such as herding, hauling water, milking, attending the needs of small stock, and the like. To counter their economic un-viability, poorer households provided services – e.g., shepherding, cooking in weddings, repairing shoes, and the like – to the well-to-do households in exchange for payment.
Despite the economic and social hierarchy, an ideology of equality formed the underlying basis of the social system (HRCP, 1994). This ethos was upheld through cultural mechanisms of wealth equalization and social welfare. Institutions such as hadiara (giving gifts or lending livestock) were among ways that qums ensured the survival of their impoverished members. In the event of an epidemic, small herd owners, ravaged by the misfortune, could rely on their relatives and friends whose larger herds were spared total decimation. Based on mutual agreements, large herd owners, who had not lost all their animals, would lend the poor herds female livestock to build up their new herds. Reimbursement could be made in installments, and borrowers usually sold the male offspring and divided the females between themselves and their benefactors. Sometimes labour was exchanged for getting new reproductive livestock, but regardless of the arrangement the devastated and impoverished households were taken care of by the more fortunate ones of their qum.

With the distribution of allotments, economic hierarchy among the Cholistani herds is no longer based solely on livestock. Although the ethos of quality still lingers, land ownership has engendered new privileges.

Because those with allotments rely on family labour, such households may face periodic labour shortage, especially during the monsoons when milking and dairying are in full swing. Labour shortage may also be felt during wheat and cotton harvesting, when hauling water and controlling animals around the irrigated perimeters demand high labour input. Because of labour shortfalls and growing dependency on cash, increasingly women are pulled into the labour market as casual labourers. This has changed the structure of nomadic households, as nowadays herding families may be divided into different segments by sending
some of their females and children to allotments to work on their own lands or those of others.

Children also benefit from their family’s ownership of land. Because of seasonal migration, pastoral families have no opportunity to educate their children and there are no mobile schools that follow the transhumance. Households with allotments, on the other hand, have permanent dwellings to accommodate their children. Although the drop-out rate is high and boys’ education is given more importance than that of girls, children from land-owning families have more educational opportunities, making them better equipped to compete in the urban labour market for jobs that require literacy.

Economic diversification in agriculture trickles down into other forms of income-generating activities. For example, some may invest in buying and renting trolleys used for transporting cottonseed cakes, wheat, people, and other goods. Tractors are used both for ploughing fields and transport. A young man of the household takes the responsibility of driving and maintaining the vehicle when it is rented. Because it is increasingly common for women and children to travel between their settlements on route to their summer and winter grazing lands, those owning vehicles can expect income during migration season.

To increase their income opportunity, young men from poor households without allotments may work as wage labourers in small market towns to take on such manual jobs as masonry and brick making. There is little labour migration to large cities like Karachi or to the oil fields in the Gulf as is common in other parts of Pakistan. Both distance and lack of cultural skills discourage large-scale out-migration from Cholistan.
6.4 Hazard perception

Perception is a central, but nebulous and controversial, concept in hazard research. Natural scientists are increasingly receptive to perception as a bridging and unifying concept for environmental management research. Hazard perception studies is a branch of the much larger field of hazard research. It is concerned with the totality of factors which generate, sustain, exacerbate, or mitigate those characteristics of natural and man-made environments that threaten human safety, emotional security and material well being (Zaidi, 1981; Saarinen et al., 1984). Hazard adjustment is a four-step process involving:

1) Assessment of the probability of natural extreme,
2) Review of alternative adjustments available,
3) Evaluation of the impacts of alternative adjustments,
4) Choice of adjustment.

The level of perception affects decision-making of Cholistani families regarding the use of rangelands. It has very important role in determining the degree of impending losses to a considerable extent (Pathak, 1991; Ahmad, 1997b). Level of perception is not uniform throughout Cholistan. Study of perception is mainly based on the filed observation, i.e. talking with and interviewing the selected respondents in sample communities.

6.5 Local perception

In this study, the Rapid Rural Appraisal Survey instrument is used to gather information on Cholistani families. A village survey instrument was employed in group interviews and farmer survey instrument was employed to record discussions with individuals. Survey was conducted in three Tehsils, Yazman, Liaquat Pur and Fort Abbas, one in each three Districts, Rahimyar Khan, Bahawalpur and Bahawalnagar respectively of Bahawalpur Division (figure 24).
Five communities were selected in each District and 30 families were interviewed in each community. There are three major constraints in conducting this survey, time, resources and accessibility to the communities. Many of the communities selected were within a three kilometer radius of a metalled or a hard surface road. Many were isolated and difficult because of poor or no roads. Survey was conducted in some communities after walking several kilometers.

Out of a total number of 450 representatives a little over half said they share in any kind of decision-making. Of these, 124 have some say only in family matters related mostly to children's marriages and visitations. However, none of them have
any say in the decision which most affects their lives, their own marriage. The marriage decision of a Cholistani girl is mostly made even before she reaches the age of adolescence. Furthermore, marriage transactions in Cholistan are very different from many parts of the subcontinent. There is dowry system, but in Cholistan, marriages are negotiated by the bride wealth system. While dowry requires the bride’s family to supplement the groom’s family wealth, bride wealth requires the groom’s family to transfer wealth to the bride’s family or exchange a bride for a bride \textit{wahi sata}. The marriage culture of Cholistan makes women slaves of their in-laws family, they all know to manage a household well and how to be loyal. Luckily, none of them knows the meaning of freedom, they and their “souls” are saved the “unforgivable sin” of committing suicide.

None of the women could speak Urdu. Since hardly any formal or informal facility of educating women is available in the surveyed communities, literacy rate of women is zero. However, most of the respondents appeared to be very conscious of the absence of this social and economic asset. However, great disadvantage is literacy, it does not make these women any less emancipated. Almost all of them earnestly cherish the wish to see their children, both boys and girls, educated. In some communities, absence of a girl school appeared to be one of the major concerns of the people. Interviews suggest that access to provisions for girls’ education is the major constraint the Cholistani communities are facing. In the surveyed communities of Liaquat Pur, the number of children between the ages of 6 to 15 is 286 of which 63 or 22\% are enrolled in school, 17\% of the boys and 5\% of the girls. In Yassan communities, the number of eligible children for school enrolment is 265 of which 80 or 30\% are enrolled in schools. The boys represent 22\% and the girls 8\%. In the surveyed communities of Fort Abbas, 190 or 52\% of the 361 eligible children go to school, 34\% boys and 18\% girls. Out of 912
children between the age of 6 to 15 in the 15 surveyed communities, 333 or 37% are enrolled in schools. When gender is taken into account, the enrolment rate for boys rises to 49% while that of girls' drops to about 23%. The low enrolment rate for girls is mainly because of the unavailability of education facilities in these communities. Most of girl's schools are not functioning because the lady teachers are not available. Minimum distance to the nearest secondary school is 20 Km, 12 Km, and 3 Km from the surveyed communities of Yazman, Liaquat Pur and Fort Abbas respectively.

The study indicated that people in the surveyed communities are mostly Seraiki speaking with a small minority speaking Punjabi. The ethnic make up of the communities surveyed is 80% Seraiki and 20% Punjabi. The total land area of fifteen surveyed communities is estimated 6,441 hectares with population of 19,500 people. In official estimates the population density of the rural areas of Bahawalpur Division is estimated at 137 persons/Km² (Government of Pakistan, 1984), but the findings show that population density in fifteen surveyed communities is 302 persons/Km²: 246, 194 and 513 persons/Km² in Yazman, Liaquat Pur and Fort Abbas Tehsils respectively. Average family size of the respondents is about seven, five kids per family. However, this number conceals more that it reveals because many of the women questioned were newly wed. Either they don't yet have children or their children are very young. Many families tend to be quite large than the average size. The women get married at an early age and because of unavailability and inaccessibility of contraceptive information and devices, run their full reproductive cycle. Many of the survey women have 8 to 12 children. A few have even larger families. There is correlation between the size of the family in any community and poverty which is extreme and widespread in the surveyed areas. Thus, the Cholistani women who have large families are making a
rational calculus for survival in their present circumstances. High birth rates reflect their defensive reaction against acute poverty.

In all surveyed communities, women scarcely have any access to medical facility. Only 8 of the 450 respondents said they have enough money to spend when they are sick, while only 5 have ever been to a lady doctor. 87% of the adults have not been vaccinated in the surveyed households. About 51% of the women reported that even their children have not been immunized against killer diseases. There are neither female doctor nor any trained birth attendants in the Basic Health Unit.

Most of the families in the surveyed communities appear to suffer protein-malnutrition. None of the women said that meat appears on their weekly menu. Only 68 of the 450, or 15%, indicated that they eat meat once a month, while more than half, 55% eat meat once a year. This occurrence is on the festival of animal sacrifice, Eid-ul-Ezha. During the period when mustard greens are in season, 67% of the women indicated that they cook them daily. They are eaten with unleavened wheat bread or, chapatti. Occasionally, the women manage to enhance their diet with vegetables or pulses but they frequently depend on availability and the amount of money they are left to spend on food. Eggs and fruits appear to be an occasional luxury for most of the households surveyed. Although majority of the women indicated that their families consume some dairy products e.g. milk, yogurt and butter but the consumption is very low. Many women said, with great pain, that several times their family's diet is reduced to eating only wheat chapatti with chillies and salt added yogurt milk.

Women in such culture perform hard tasks without being counted as member of the labour force. Table 16 gives the daily time allocation pattern of the in surveyed communities to various productive activities. Table contains hourly estimates of women's time spent on activities with and beyond the household in the surveyed
communities. Although life is very simple in Cholistan, yet women commit quite long hours to "ordinary, everyday kinds of activities" within the home, activities which are taken for granted: food preparing, washing clothes and dishes, cleaning up etc.

Apart from water carrying, all the 450 respondents have to go outside the home for gathering firewood for household consumption. Sometimes, the activity involves walking long distances in the desert to find wood. The women indicated that mostly they go for gathering firewood once or twice a week. Daily average spent by each of them on this activity is 45 minutes. About 64% of the households in the surveyed communities use firewood as a main source of energy and about 36% use a combination of firewood and cow dung as a means for cooking or for providing heat during the winter season.

Pastoralism is an important enterprise for most of the families in the Cholistani communities. Of the 450 households interviewed, 404 or 90% were involved in pastoral activities. The average herd size for each community surveyed was 830 herds of cattle, 480 sheep, 580 goats, 42 buffalo, and 25 camels. Of the 450 women interviewed, 393 were involved in livestock management activities, spending each on average about two and half hour daily.

The cultural model in Cholistan assumes that men are the economic providers whose role is variable and dynamic, while the women are domestic consumers whose role is essentially static. Finding suggests that women's economic behaviour in Cholistan is not as dependent as often assumed and that, given the widespread poverty in the area, their behaviour is almost uniform. Women make vital economic contributions not only for their own support but also for the support of their family.
Table – 16

DAILY ALLOCATION OF WOMEN’S TIME TO WORK

<table>
<thead>
<tr>
<th>Category</th>
<th>Average time (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Work:</td>
<td></td>
</tr>
<tr>
<td>Food cooking</td>
<td>2:15</td>
</tr>
<tr>
<td>Household chores</td>
<td>2:45</td>
</tr>
<tr>
<td>Water and Energy:</td>
<td></td>
</tr>
<tr>
<td>Water carrying</td>
<td>1:00</td>
</tr>
<tr>
<td>Firewood gathering</td>
<td>0:45</td>
</tr>
<tr>
<td>Farming:</td>
<td></td>
</tr>
<tr>
<td>Planting</td>
<td>2:45*</td>
</tr>
<tr>
<td>Weeding</td>
<td>1:15*</td>
</tr>
<tr>
<td>Harvesting</td>
<td>6:00*</td>
</tr>
<tr>
<td>Livestock Management:</td>
<td></td>
</tr>
<tr>
<td>Feeding</td>
<td>2:00</td>
</tr>
<tr>
<td>Milking</td>
<td>0:30</td>
</tr>
</tbody>
</table>

*Seasonal activities.

Source: Based on field survey; June 2000.

6.6 Infrastructure:

6.6.1 Roads

Draft animals and carts are used extensively for transport throughout Cholistan, while motorbuses and tractors are the principal means for human transport and the movement of crops and construction materials. All of these depend on an inadequate road system where traffic movements are chaotic and precarious because of the mixed nature and speeds of the various kinds of motive power, frequent congestion especially around villages, and the typically very poor state of the road surfaces and foundations which carry traffic loads well in excess of their design capacity or structural quality (table 18).

6.6.2 Electricity

Greater Cholistan lacks electricity and supplies are not justified. Some villages in Lesser Cholistan are supplied, and the Cholistan Development Authority has
recommended extension of the supply to 55 chaks and abadies. A plan of the existing electrical distribution grid was sought from the appropriate authority, but was not forthcoming, CDA official said.

6.6.3 Water supply and sewerage

The Department of Public Health Engineering provides domestic water and some sewerage in the rural areas of Cholistan, services now incorporated with a Tameer-e-Watan Programme sponsored by the Government of Pakistan.

To date (January 1998), about 30% of the rural areas have been supplied with scheme water, but the funds available are inadequate to meet the demand of an increasing population. CDA official said. Some schemes installed five years ago are already inadequate. Some 130 new schemes for water supply (70) or sewerage drainage (60) are planned for 1997/98, but this target is unlikely to be achieved because of lack of funds.

Department policy is not to provide water in those areas where sweet groundwater is readily available within 15 meter depth and which can be taken by a hand pump. In other areas where water was provided, the community was expected to operate and maintain the system after two years. However, the Government has had to resume responsibility because many communities would not, or could not, maintain the system.

Cholistan Development Authority (CDA) is occasionally sampled the water from wells for chemical purity. A few of the analyses inspected at random showed that water properties were well within World Health Organization permissible levels (table 17), and most were within desirable levels except for total dissolved solids (828 mg/l) and total hardness at 230 mg/l as CaCO₃. Bacterial counts are made
when complaints arise and remedial measures applied if warranted. The Department cannot afford to supply chlorination plants, CDA official said.

Table – 17

<table>
<thead>
<tr>
<th>Mineral contents</th>
<th>Permissible level</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (soluble ions)</td>
<td>7.3</td>
</tr>
<tr>
<td>Calcium (mg/l)</td>
<td>50.1</td>
</tr>
<tr>
<td>Magnesium (mg/l)</td>
<td>5.0</td>
</tr>
<tr>
<td>Sodium (mg/l)</td>
<td>10.0</td>
</tr>
<tr>
<td>Sulphate (mg/l)</td>
<td>20.0</td>
</tr>
<tr>
<td>Fluoride (mg/l)</td>
<td>0.5</td>
</tr>
<tr>
<td>Bicarbonate (mg/l)</td>
<td>25.4</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>89.0</td>
</tr>
<tr>
<td>TDS (total dissolved solids) (mg/l)</td>
<td>350.0</td>
</tr>
</tbody>
</table>


Table – 18

FACILITIES THROUGH VARIOUS DEVELOPMENT PROJECTS IN CHOLISTAN

Education

<table>
<thead>
<tr>
<th>No. of high schools</th>
<th>No. of middle schools</th>
<th>No. of primary schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>Girls</td>
<td>Total</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Roads
- Metalled road: 48.77 miles
- Brick road: 3000 miles
- Small bridges on channels: 100 No.

Water resources
- Tubus (Kuchi): 598
- Cemented tubus: 021
- Wells: 011
- Tubewell: 001
- Water reservoir (Kundi): 016
- Ponds: 044

People’s health centres
- Civil dispensaries: 06
- Basic health unit: 06
- Mobile dispensaries: 03
- Rural health centre: 01
Health services for livestock
- Veterinary centres 03
- Veterinary hospitals 11
- Mobile veterinary hospitals 05

Source: CDA – Cholistan Development Authority, 1996.

6.6.4 Public health

A hospital official in Bahawalpur suggested that the main public health (figure 25) issues in Cholistan were lack of sanitation, the high level of illiteracy and a lack of forward planning regarding the disposal of sewerage in settled areas.

Sewerage would not be an issue in the arid, nomadic parts of Cholistan although faces might be a risk around the semi-permanent settlements. However, Cholistanis would be exposed to a health risk from sewerage during their seasonal sojourn in the irrigation area. The hospital experienced mortality rates of 0.106 and 10% for mothers and infants respectively in 1997/98. The hospital (table 18) expects the rural maternal mortality rate would rise to 0.6% because of untrained midwives being in attendance.

6.7 Quality of life

Quality of life issues are classified into those, which affect the community of Cholistan as a whole, and those which are part of the fortunes or misfortunes of the individual’s lot.

Quality of life for the community is under the charter of Environmental Protection Authority of the Punjab, amongst the foremost of such organizations in Pakistan. The main concern of the authority at present is the extraordinary high levels of water pollution in Bahawalpur Division. These levels directly affect the populace of Cholistan because these polluted waters are probably introduced by the canal system from the rivers. Surprisingly, analytical data could not be found for canal water in Cholistan.
A public awareness campaign is the main approach used by the Authority to improve the situation because it lacks adequate resources. Contaminated water nevertheless probably continues to reach the Cholistan canals. Unless special plans were made, the Authority would evidently not be in a position to monitor or enforce environmental standards required for any project if their resource base was kept at present levels.

The roads pose a threat to the quality of life for the community. Localized, high concentrations of atmospheric pollution from dust and vehicle exhausts, bad roads and appalling standards of traffic control, offer the possibilities of gradual suffocation, injury or death.

At the individual level of quality of life, it would be of interest to examine the reasons why increasing amounts are spent in obtaining medical services with increasing poverty. All sectors have access to the polluted canal water, the wealthy might have greatest contact since they are most likely to own irrigated land. The reason might lie in inadequate nutrition or housing, or in health practices (lack of sanitation for the poor, lack of water treatment before drinking, or non-canal water may be even dirtier). Low levels of literacy, especially amongst women, probably contribute towards a low quality of life.

Progression towards a higher socio-economic stratum and hence a better quality of life, for the poor might lie through improving literacy, (4 per 1,000 adults, 8 per 1,000 children) the opportunity for education, improved wages and conditions for labour, and better access to health services at less cost. This would make more income available for purchasing food and other necessities. Ownership of more livestock, without certainty of access to adequate grazing land or reasonably-priced fodder, may be more of a hindrance than help. Title to irrigated land should rapidly increase the quality of life.
However, the finite resources of irrigable land and water are already insufficient to meet the demands of the present population. This message should be clearly spelled out as part of an education programme especially aimed at women. The alternative options, such as family planning could be appreciated best by an educated mother.

6.8 Conclusion

The condition of health and sanitation among Cholistan herding communities are poor. Disease, exacerbated by periodic under nutrition, is rampant, and herders expend considerable sum on often dubious medical procedures and drugs. Special attention should be given to women's health issues, since women suffer high rates of morbidity but are culturally discouraged from discussing female-specific health problems. Conditions of health and sanitation are further exacerbated by periodic shortages of safe, reliable drinking water.

Education for pastoralists can be most effectively organized through an institution that directly involves them in educational programmes, which emphasis on the management of their resources. The use of radio and TV as a medium of communication with Cholistani pastoralists should be exploited. Radio and TV programmes should be broadcast in the local language. These programmes should provide an opportunity for further learning regarding climate and the pastoral life, vegetation and land use, destructive effects of over-grazing on vegetation and land resources, livestock marketing, livestock diseases and veterinary inputs.
CHAPTER – 7a

RESOURCE EVALUATION:
PLANT GENETIC RESOURCES IN CHOLISTAN

7a.1 Overview

Cholistan is rich in vegetation resources that can be exploited on commercial basis. The area was once green and prosperous, where cultivation was practiced. The source of irrigation was Hakra River (Akbar et al., 1996). With the drying up of the river, the area was deserted through desertification processes and only few grazing lands were left.

Drinking water and shortage of forage grasses are the main causes of low yield of livestock in Cholistan. When there is no rain during the year, then water and fodder become very severe problems for the people and livestock. As a result of drought the people are compelled to leave the area in search of water and fodder. They migrate towards irrigated lands. They stay there till the rains occur in Cholistan. After rains, Cholistan becomes green and rich in forage grasses. Consequently, carrying capacity of forages increases and more production from livestock is achieved. Grazing lands of Cholistan contribute a big share in the country’s livestock production (Associated Press of Pakistan, 2000).

7a.2 Plant genetic resources

Cholistan is rich in vegetation resources, the projective aspect helps in soil binding, windbreaks and shelters belt establishment, while the inhabitants use productive aspect for themselves and their animals (Arshad and Rao, 1994a).
The most common plants used as supplement of cereals are *Cenchrus ciliaris*, *Cenchrus biflorus* and *Cenchrus prieurii*. These grasses are very widely distributed in Cholistan. During the famine and drought years, the seeds of these grasses are ground in flour and used as a supplement (Arshad *et al.*, 1999).

The grains of *Panicum antidotale*, *Panicum turgidum* (Rao *et al.*, 1989; Rao and Arshad, 1991; Arshad and Rao, 1994a) are also consumed as food during the famine years. *Panicum antidotale* and *Panicum turgidum* are very drought resistant and found on the high sand dunes and perpetuate by their hardy rhizomes and seeds. They also protect themselves from overgrazing because of their hard and unpalatable stubble. The seeds of both species are ground and mixed with other cereals.

*Indigofera argentea* is a wild legume and mostly found during the monsoon on the top of very high sand dunes of Greater Cholistan. During the drought years, the seeds of this herbage are also ground and mixed with other cereals.

In Cholistan, a number of plants are used as vegetables. *Capparis decidua* locally called, ‘Kavir’ is important perennial shrub, leafless, much branched and evergreen plant used as vegetables frequently.

*Prosopis cineraria* locally called, ‘Kaudi’ is an excellent survivor of Cholistan desert. Camels, cows, goats and other animals browse it and give flowers and fruits during the month of March to May. The young green pods are cooked as vegetables in addition to fresh and preserved forms. The yellowish mature pods are sweetish in taste and are eaten directly.

*Calligonum polygonoides* locally called, ‘Phog’ is an abundantly growing plant species on the sand dunes. The flower buds of this plant locally called as ‘Phugusi’
are cooked in fresh form and also dried in sunlight for its later use. *Caralluma edulis*, locally known as ‘Settu or Pippu’ grown abundantly in the spiny bushes of *Prosopis cineraria* and *Capparis decidua* after monsoon rainfall. It is a very delicious vegetable of the season and people cook it directly. The inhabitants use the fruits of *Capparis decidua*, *Zizyphus spina christi* and *Salvadora oleoides*.

There are seeds of many indigenous species, which posses considerably a high percentage of oil. *Citrus colocynthis* is a perennial trailing herb with fruit of sandy tract, containing 15 percent of pulp, 23 percent vind and 62 percent seeds (Sen, 1982). The seeds contain 21 percent of non-edible oil, whose paling is always brown in colour and very bitter in taste. Under natural conditions 50-80 creepers per hectare are recorded bearing 8 to 50 fruits per creeper. The oil obtained from this plant is used in the soap industry. It has high medical value for joint pains in human and stomach ailment in animals (Arshad et al., 1987).

*Salvadora oleoides* locally known as ‘Jal’ is evergreen, its small trees grow in habitats having medium to fine textured soil. The fruit of this plant is edible and liked very much by the local inhabitants. There are numerous aromatic plants in Cholistan, which contain essential oils having strong dour aromatic. The essential oils can be removed from the plant tissues and can be used in the perfumery and soap industries. The common species are *Cymbopogon jwarancusa*, *Cymbopogon marttinni* and *Cyperus rotundus* (Arshad and Rao, 1993).

The important plant species used as wind breaks and shelters belt are *Prosopis juliflora* (Valyati Kiker), *Tamarix aphylla* (Frash), *Prosopis cineraria* (Jandi) and *Acacia nilotica* (Kiker).
7a.3 Development of under-utilized industrial and medicinal plants

There are many desert plants in Cholistan, which are under-utilized, but have significant industrial and medicinal values. Similarly the new desert plant such as *Simmondsia chinensis* and *Agave sp.* should be tried here. *Simmondsia chinensis* is a drought resistant plant. It contains 45 to 55 percent lubricating oil known as liquid wax and is used in pharmaceutical industry. The *Agave sp.* produce 5-7% fibre which can be used for cordage, twine, carpet base etc. Development of such under-utilized plants and their market should be undertaken with the objective of providing alternate sources of income to the people of Cholistan. For instance, many new industrial processes can stimulate the need for a large supply of plant products like lubricating oils, waxes, pharmaceuticals etc. Some of these plants of economic value and their uses are given below (Arshad et al., 1987; Rao et al., 1989 and Arshad and Rao, 1993):

7a.3.1 Fibre plants

i) *Leptadenia pyrotechnica* (Khip),

ii) *Crotalaria burhia* (Chag),

iii) *Agave sp.*

iv) *Calotropis procera* (Its stem contains 4-5% fine fibre).

7a.3.2 Oilseed (non-edible)

i) *Citrullus colocynthis* (Lumba): Contains 20% oil

ii) *Citrullus lanatus* (Matera): Contains 20-30% oil
iii) *Simmondsia chinensis* (Jojoba): Its seeds contain 45 to 55% lubricating oil

iv) *Salvadora oleoides* (Jal): Non-edible

v) *Salvadora persica* (Jal): Oil seed plant

vi) *Azadirachta indica* (Neem)

vii) *Pongamia pinnata* (Pit papri)

viii) *Balanites aegyptiaca* (Hingota)

### 7a.3.3 Gums

*Genus Acacia* is the main source of gum in arid zones.

i) *Acacia senegal*: Produces gum

ii) *Acacia nilotica*

iii) *Acacia leucophloea*: Produces brown gum

iv) *Acacia cupressiformis*: Produces red gum tears

v) *Acacia tortilis*

vi) *Prosopis juliflora*: Produces black gum tears

### 7a.3.4 Herbal plants

Some of the un-exploited desert flora of important medicinal value is given:

i) *Cymbopogon jwarancusa* (Khavi),

ii) *Cassia augustifolia* (Senna).
iii) *Plantago ovata* (Isabgol),

iv) *Datura innoxia* (Datura),

v) *Trichobis terrestris* (Hakkari),

vi) *Commiphora wightii* (Gugal),

vii) *Boswellia serrate* (Salarn),

viii) *Solanum nigrum* (Mako),

ix) *Cucurbita foetidissima* (Buffalo gourd).

7a.3.5 Pharmaceuticals

The following chemicals can be isolated from different desert flora. Isolation of such products of economic value should be taken up.

i) Diosgenin from *Balanites roxburgii*,

ii) Scopolamine from *Datura innoxia*,

iii) Cineole from *Eucalyptus vividis*,

iv) Candelilla wax from *Euphorbia antisypilitica*,

v) Essential oil from the leaves of *Cymbopogon martinii*,

vi) Crude soda from *Haloxylon recurvum*.

7a.3.6 Miscellaneous plants

*Parthenium argentatus* (Gwayle) : All parts of the shrub contain rubber-like substance.
Soft wooded species like *Ailanthus excelsa* and *Moringa oleifera*, if grown in Cholistan, can feed the matchstick and paper industry. Similarly, some of the perennial desert grasses such as *Panicum antidotale* (Gramma), *Saccharum munja* (Munja), *Heteropogon contortus* have potential of being used in the paper industry (Arshad and Rao, 1994a).

7a.4 Native plants as a source of food during famine

Desert dwellers, especially the nomadic communities of desert tracts, partially depend on natural vegetation and wild life species for their food during prolonged droughts and famines. They collect fruits, seeds, leafy material and roots of the native plants for consumption. Under extreme famine conditions even the bark of a hardy plant like *Prosopis cineraria* may be consumed. Experience of generations has taught them well how to survive under the harsh desert environment. Some of these native famine food plants are mentioned as under:

7a.4.1 Wild fruits

Fruits of many native plants may be eaten raw, while those of others can be dried and preserved for future use, such as *Zizyphus nummularia* (Jangli beri), *Cordia myxa* (Lasoora), *Cordia ghauf* (Lasoori), *Capparis decidua* (Karir), *Prosopis cineraria* (Khejri), *Salvadora oleoides* (Pilu), *Opuntia sp.* (Thor), *Azadirachta indica* (Neem), *Ficus religiosa* (Peepal), *Ficus bengalensis* (Bargad), *Acacia senegal* (Kumat), *Cucumis callosus* (Kachra), *Cucumis lanatus* (Matera), etc.

7a.4.2 Seeds

Seeds of some grasses like *Cenchrus ciliaris* (Dhawan), *Cenchrus setigerus* (Anjan or Dammi), *Cenchrus biflorus* (Bhurat), *Lasianthus sindicus* (Sewan), *Panicum antidotale* (Gramma), *Panicum turgidum* (Murat) and *Eleusine compressa* (Tantia)
can be collected and used with bajra grain as a suitable mixture. Seeds of creepers namely Citrullus colocynthis (Tumba), Citrullus lanatus (Matera) and those of a few legumes like Indigofera and Acacia species can also be consumed in different ways.

7a.4.3 Leafy material

Leaves of herbs such as Achyranthus aspera, Gisekia Pharmacoides, Lencus aspera, Boerhavia diffusa and Boerhavia verticillata can be used after boiling.

7a.4.4 Roots

The root tubers and rhizomes of desert plants are used during famines. Young roots of Butea monosperma (Dhak), Bombax cieha (Semal), Seropigia tuberosa (Khudala) are roasted and eaten raw. Swollen roots of Asparagus racemosus are also used. Rhizomes of Cyperus sp. (Motha) can be used after boiling under severe famine conditions.

7a.5  Khip—silver fibre of Cholistan desert

‘Khip’, Leptadenia pyrotechnica is an evergreen herb plant. In winter, the plant turns pale and dry, in rainy season again turns green. It requires sandy soil to grow. At the initial stage, its root growth is very quick and deeper probably more than its stem growth and depends on the type of soil (Laghari, 1991). Its seed has silky coma, therefore are carried to a considerable distance by the wind. The healthy plant normally occupies 100 to 150 feet$^2$ of land. Its normal height is five to eight feet and we can take benefit preferably after two years of its plantation. ‘Khip’ plant belongs to xerophytic class and is a perennial plant. Every year new sprouts shoot up which have comparatively less wood and thicker bark, which bear fibre. The plantation of ‘Khip’ will not only changes the economy of the local people but
also even changes the climatic conditions. The brackish water of Cholistan would be helpful in the growth of the plants because it does not spoil faster (Laghari, 1991). Its plantation season is launching of the monsoon and starts flowering in February. It bears pod full of seeds with silky coma. The seeds are matured in April and can be used for oil extracting. The stem of the plant after taking out fibre can be utilized in paper industry for making hard wood. ‘Khip’ is also used in pharmaceutical industry and ash of ‘Khip’ is used for removing kidney stones. ‘Khip’ is also used as fodder for camels and goats.

7a.6  **Jojoba—an economic oilseed plant**

Besides, the fossil-fuel crisis and its scarcity, arid plants can be replaced as a source of raw material of petroleum and mineral oil products in future. Many arid plants, such as jojoba, *Atriplex spp.* and local habitats like ‘pilu’, ‘khip’, ‘beri’, ‘khar’ etc. grow well on marginal dry and light textured soils and brackish water of drylands can be used for irrigation purposes. Jojoba is known as valuable specie of arid lands, its seeds contain 45 to 55 percent lubricating oil. Jojoba oil is used in cosmetics, pharmaceuticals and lubricant industries (Butt *et al.*, 1991). The life of Jojoba plant is expected ranging from 100-150 years can tolerate and adjust with different adverse environments, *i.e.* extreme temperature, drought, salinity and frost except water logging.

7a.6.1 Physical properties

Jojoba pronounced ‘HOHOB.A’, its scientific name is *Simmondsia chinensis* belongs to the family Euphorbiaceaeus. The crude oil of Jojoba contains 97 percent wax ester and refining is not required for use in the most industrial application. The physical properties of oil are given in table 19.
Table 19

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetyl</td>
<td>2</td>
</tr>
<tr>
<td>Acid value</td>
<td>2</td>
</tr>
<tr>
<td>Average molecular weight of wax ester</td>
<td>606</td>
</tr>
<tr>
<td>Boiling point</td>
<td>398°C</td>
</tr>
<tr>
<td>Dielectric constant (270°C)</td>
<td>2.680</td>
</tr>
<tr>
<td>Fire point</td>
<td>338°C</td>
</tr>
<tr>
<td>Flash point</td>
<td>295°C</td>
</tr>
<tr>
<td>Freezing point</td>
<td>19.6-7.0°C</td>
</tr>
<tr>
<td>Iodine value of acid</td>
<td>76</td>
</tr>
<tr>
<td>Iodine value of alcohol</td>
<td>77</td>
</tr>
<tr>
<td>Melting point</td>
<td>6.8-7.0°C</td>
</tr>
<tr>
<td>Refractive index at 25°C</td>
<td>1.4650</td>
</tr>
<tr>
<td>Smoke point</td>
<td>195°C</td>
</tr>
<tr>
<td>Total acids</td>
<td>52%</td>
</tr>
</tbody>
</table>

Source: Jojoba Research Station, Bahawalpur.

7a.6.2 Methodology

Jojoba plant is believed an expected arid plant, which can tolerate brackish water and other hazard of arid lands (Butt et al., 1991). The Jojoba plants could be successfully raised providing appropriate technology for shielding the seedling until they establish their root system to compete with the environmental stress, however, arrangements of irrigation water, even brackish water is available in Cholistan, need to be assured in the early years’ growth of Jojoba. The experiment of Jojoba plantation at Dingarh, Cholistan initiated by Pakistan Council of Research in Water Resources (PCRWR) and technical data, observations were taken periodically by Jojoba Research Station. Data is given in tables 20 and 21. Four different methods, furrow irrigation, pitheber irrigation, sprinkler irrigation and drip irrigation have been adapted at research station in Dingarh and net income of ten years is given in tables 22, 23, 24 and 25.
Table – 20

JOJOBA PLANTS SURVIVAL CO-EFFICIENT SINCE OCTOBER 1988

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of plants transplanted</th>
<th>January 1989</th>
<th>April 1989</th>
<th>September 1989</th>
<th>March 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedlings without PVC pipe</td>
<td>253</td>
<td>80</td>
<td>75</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Seedlings with PVC pipe</td>
<td>126</td>
<td>100</td>
<td>89</td>
<td>85</td>
<td>83</td>
</tr>
</tbody>
</table>

Source: Jojoba Research Station, Bahawalpur.

Table – 21

FREQUENCY DISTRIBUTION OF HEIGHT OF JOJOBA PLANTS SURVIVED AT DINGARIH UPTO MARCH 1990

<table>
<thead>
<tr>
<th>Range of height (Cm)</th>
<th>Class frequency</th>
<th>Percentage of Survivors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 20</td>
<td>12</td>
<td>11.43</td>
</tr>
<tr>
<td>21 ... 30</td>
<td>24</td>
<td>22.86</td>
</tr>
<tr>
<td>31 ... 40</td>
<td>29</td>
<td>27.62</td>
</tr>
<tr>
<td>41 ... 50</td>
<td>15</td>
<td>14.29</td>
</tr>
<tr>
<td>51 ... 60</td>
<td>16</td>
<td>15.24</td>
</tr>
<tr>
<td>61 ... 70</td>
<td>06</td>
<td>5.71</td>
</tr>
<tr>
<td>Above 70</td>
<td>03</td>
<td>2.86</td>
</tr>
</tbody>
</table>

Population mean height: 37.18 Cm.

Source: Jojoba Research Station, Bahawalpur.

7a.6.3 Climate

The plant can be cultivated in desert or semi-desert conditions where annual rainfall is 5 to 18 inches and temperature ranging from 6 to 51°C and can be planted from sea level to 5000 feet above sea level. The mean summer temperature in drylands is 41.2°C, while mean winter temperature is 19°C, sometime temperature reaches as high as 51°C and low as -2°C. The average wind speed varies from 11.44 to 43.41 miles/hour around the year and sometime reaches to 90
### Table 23

<table>
<thead>
<tr>
<th>Year</th>
<th>Initial (Rs)</th>
<th>Labour Cost (Rs)</th>
<th>Cultivation (Rs)</th>
<th>Picking (Rs)</th>
<th>Threshing (Rs)</th>
<th>Total Expenditure (Rs)</th>
<th>Net Income (Rs)</th>
<th>Yield (Kg)</th>
<th>Rate/Kg (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>56000</td>
<td>12000</td>
<td>7000</td>
<td>500</td>
<td>22000</td>
<td>33000</td>
<td>48000</td>
<td>100</td>
<td>480</td>
</tr>
<tr>
<td>2001</td>
<td>65000</td>
<td>14000</td>
<td>7200</td>
<td>520</td>
<td>22000</td>
<td>33200</td>
<td>48000</td>
<td>100</td>
<td>480</td>
</tr>
<tr>
<td>2002</td>
<td>75000</td>
<td>16000</td>
<td>7400</td>
<td>540</td>
<td>22000</td>
<td>33400</td>
<td>48000</td>
<td>100</td>
<td>480</td>
</tr>
<tr>
<td>2003</td>
<td>85000</td>
<td>18000</td>
<td>7600</td>
<td>560</td>
<td>22000</td>
<td>33600</td>
<td>48000</td>
<td>100</td>
<td>480</td>
</tr>
<tr>
<td>2004</td>
<td>95000</td>
<td>20000</td>
<td>7800</td>
<td>580</td>
<td>22000</td>
<td>33800</td>
<td>48000</td>
<td>100</td>
<td>480</td>
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<tr>
<td>2005</td>
<td>105000</td>
<td>22000</td>
<td>8000</td>
<td>600</td>
<td>22000</td>
<td>34000</td>
<td>48000</td>
<td>100</td>
<td>480</td>
</tr>
<tr>
<td>2006</td>
<td>115000</td>
<td>24000</td>
<td>8200</td>
<td>620</td>
<td>22000</td>
<td>34200</td>
<td>48000</td>
<td>100</td>
<td>480</td>
</tr>
<tr>
<td>2007</td>
<td>125000</td>
<td>26000</td>
<td>8400</td>
<td>640</td>
<td>22000</td>
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<tr>
<td>2008</td>
<td>135000</td>
<td>28000</td>
<td>8600</td>
<td>660</td>
<td>22000</td>
<td>34600</td>
<td>48000</td>
<td>100</td>
<td>480</td>
</tr>
<tr>
<td>2009</td>
<td>145000</td>
<td>30000</td>
<td>8800</td>
<td>680</td>
<td>22000</td>
<td>34800</td>
<td>48000</td>
<td>100</td>
<td>480</td>
</tr>
</tbody>
</table>

**Source:** Jodhpur Research Station, Bikaner
<table>
<thead>
<tr>
<th>Year (Rs)</th>
<th>Labour Cost (Rs)</th>
<th>Cultivation (Rs)</th>
<th>Irrigation (Rs)</th>
<th>Sprinkler Irrigation (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
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<tr>
<td>9</td>
<td>0</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Expenditure & Income From One Acre of Jowaria Planted by Drip Irrigation (Year Wise)

Table - 25

Source: Jowaria Research Station, Behawargan

Expenditure & Income From One Acre of Jowaria Planted by Sprinkler Irrigation (Year Wise)

Table - 24
miles/hour, these climatic conditions are favourable for the plantation of Jojoba in Pakistan.

7a.6.4 Soil

It can be grown in sandy (even on sand dunes) to sandy loam soil, pH (soluble ions) of the soil should be ranged from 5 to 8, TSS (total soluble salts) ranged from 300 to 1200 ppm (part per million). Organic matter, phosphorus and potassium ranged from 0.2 to 0.7 percent, 2.2 to 7.4 percent and 110 to 298 ppm respectively.

7a.6.5 Spacing

Row to row (R×R) spacing varies from 10 feet to 16 feet and plant to plant (P×P) from 4 feet to 6 feet. However, R×R = 12.50 feet and P×P = 4 feet is recommended for irrigated land and R×R = 10 feet and P×P = 6 feet is recommended for sand dunes.

7a.6.6 Sowing time and methods

Optimum temperature for germination of Jojoba seed is 25 to 35°C. March is the best sowing time for Jojoba. Sowing methods are given below:

7a.6.6.1 Direct sowing

In this method land is prepared and seeds of Jojoba are directly sown in the field.

7a.6.6.2 Indirect method

In this method polythene bags of size 9 inch × 3.5 inches are filled with sand + silt in equal ratio, seeds of Jojoba are sown at the depth of half inch and watered with a
hand shower thrice a day. After a month of germination seedlings are ready for transplanting in the field.

7a.6.7 Irrigation and quality of water

Inspite of desert shrub, it requires excessive irrigation during first two or three years. After plantation, the shrub requires irrigation at flowering (September – October) and fruiting (March – April) stages. Sub-soil brackish water having ECₑ (electrolyte conductivity) ranging from 3.56 to 4.9 dS m⁻¹ and SAR (sodium adsorption ratio) ranging from 12.42 to 14.58 can be used for irrigation purposes.

7a.6.8 Harvesting

Jojoba plants are ready for harvesting during May or June. After six years, the yield per plant ranges from 2 Kg to 4.5 Kg.

7a.6.9 Plants per acre

According to recommended spacing, 765 plants are transplanted for single plantation and 1530 for double plantation.

7a.6.10 Seed rate

Weight of the Jojoba seed ranges from 0.5 to 1 gram and average number of seeds in one Kg are 1600. Germination of the seeds has been found from 60 to 90 percent. In this way 2.5 Kg of Jojoba seeds are required for double sowing.

7a.6.11 Male female ratio

Male to female ratio may vary from 1:6 depending upon wind velocity of the area during the time of pollination. However, in Cholistan 100 male and 665 female plants per acre are recommended.
7a.6.12 Fertilizer

Fertilizer of 50-50-50 N-P-K (Nitrogen-Phosphorus-Potassium) lbs./acre at flowering stage (September) imparts good result on yield.

7a.6.13 Intercropping

After six years, other crops can be easily intercropped in Jojoba. Leguminous crops like gram and mung also improves the growth and yield of Jojoba. Other crops like oat or vegetable can be sown leaving one-foot distance on both sides of the Jojoba row.

7a.7 Conclusion

The analysis of Cholistan desert resources help us to know that the desert tract is full of plant resources, which have not been exploited on a large scale or commercial basis, because of their low output, sparse distribution and very poor management. For the overall development of the desert, it is an urgent need that the existing plant resources should be exploited on sound scientific lines.

It is essential that land-based activity, aimed at combating desertification, restoration of ecological balance by utilization of rainwater and improvement in the rural economy by creating stable resource based and increased employment opportunities, decision of participating people becomes paramount to fulfill the needs and interests of individuals and institutions concern. Initiation of such programmes evolved with effective tackling of all inter-related social, economic and environmental issues prevailing in the society that necessitates a comprehensive and relevant policy, administrative and technological framework which promote the programme efficiency by involving local communities in the process of combating desertification and restoring the ecological balance.
CHAPTER – 7b

POSSIBILITIES FOR RANGE DEVELOPMENT AND ITS DISTRIBUTION IN CHOLISTAN

7b.1 Overview

Range management has been defined as the science and the art of optimizing the returns from rangelands in those combinations most desired by and suitable to society through manipulation of range ecosystems. Rangeland is defined as land on which the native vegetation is predominantly grasses, grasslike plants, forbs or shrubs suitable for grazing or browsing use (Khan, 1992).

The rangelands of Cholistan have been subjected to very heavy grazing which has resulted in elimination of much of the desirable herbaceous vegetation, and an increase in abundance of less palatable plants. Proper range use requires controlled grazing, to provide for the growth requirements of desired forage plants, to prevent soil deterioration, and to allow sustained maximum animal production. This can only be achieved with a thorough understanding of the range resources and the main objective of any range development programme (Khan, 1992; Mohammad, 1994).

In connection with the development of rangelands in Cholistan, watering points are essential items. Wells and waterponds (dug-in-tobas) could be found at a few and are not located at appropriate places. As a result, water is destroyed rapidly and cannot be used for longer period. It may be worthwhile to record that sheep and cattle can consume brackish water (plate 2) with salt content upto 7,000 ppm (Baig et al., 1980) and camel and goats upto 15,000 ppm without any negative effects on
One of the deep wells on the way to Islamgarh supplying brackish water for animals

Plate 2
their health. Highly saline water containing 10,000-35,000 ppm may also be used seasonally by the livestock provided that the proportion of divalent cations and anions notably magnesium sulphate and carbonate is low (Baig, 1978; 1982).

Physiographically, vegetation of Cholistan belongs to the Nubo-Sindhiian Province of the Sudan (FAO/ADB, 1993). The genets are essentially tropical and are adapted to the rhythm of long summer days and a rainy season and short winter days with a dry season. The vegetation is typical of arid regions and consists of xerophytic species, which are adapted to the extreme seasonal temperature and moisture changes. The principal adaptation is, however, to the scarcity of moisture. All the species are self-generating and self-maintaining under normal grazing (Baig et al., 1975; Mohammad, 1991).

Vegetation cover is superior in the eastern arid (Figure 26) part (200 mm rainfall) of Cholistan due to better moisture conditions than in the hyper arid west (125 mm rainfall). The vegetation is remarkably uniform with same dominants throughout Cholistan.
The vegetation occurs in four major communities (FAO/ADB, 1993):

i) Shrubland grows typically on sand dunes and ridges which are excessively well-drained and liable to wind erosion;

ii) Shrub-Grassland occurs in valleys, especially where a layer of sand up to two or three meters deep overlies a relatively impermeable loam or clay stratum. These sites receive extra runoff and moisture conditions are optimal;

iii) Sparse succulent steppe on flat valleys of loamy or clayey soils, usually saline or saline-sodic and with poor infiltration properties. Soil moisture conditions are minimal, but the sites are ideal catchment for toba and kund development; and

iv) Remnant Tree Groves mostly located where the toe-slopes of dunes encroach over the perimeter of flat valleys.

Based on differences in topographic form, parent materials, soil and vegetation, Cholistan can be conveniently divided into two main geomorphic regions (figure 27). The southern region (Greater Cholistan) is a wind resorted sandy desert comprising of a number of old river terraces with various forms of sand ridges and inter ridge valleys. The northern region (Lesser Cholistan) constitutes the desert margin and consists of a series of saline alluvial flats alternating with low sand dunes.

7b.2 Desert margin (Lesser Cholistan)

This region lies 2-4 meters below the wind resorted sandy desert (Greater Cholistan). It consists of a complex of two distinct terraces separated by a bluff ranging in height from about half a meter to three meters (FAO/ADB, 1993; Tahir et al., 1995). The terraces are:

a) Sub-recent clayey terrace (10,000-1,000 years ago).
b) Dissected wind resorted sandy terrace of Hafizabad stage (17,000-10,000 years ago).

The sub-recent terrace is lower and comprises the saline alluvial flats causing the sub-recent channels of the drying Hakra River (Tahir et al., 1995). The sediments of this terrace are predominantly clayey and the soils are invariably saline or saline-sodic (Baig et al., 1980). The vegetation cover, which consists of xeromorphic halophytic plant species, is a true indicator of the saline soils of the region.

CHOLISTAN DESERT

FIG. 27

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 and bear a vegetative cover consisting of true desert shrubs similar to those of the Greater Cholistan.

7b.3 Wind resorted sandy desert (Greater Cholistan)

In all, three terraces have been distinguished in the wind resorted sandy desert formed during different stages of Pleistocene period. Each terrace is separated from the other by a bluff ranging in height from about one to six meters (FAO/ADB, 1993; Tahir et al., 1995). The terraces are:

a) Wind resorted sandy terrace of Hafizabad stage (Late Pleistocene, 17,000-10,000 years ago).

b) Wind resorted sandy terrace of Wazirabad stage (Late Pleistocene, 50,000-20,000 years ago).

c) Wind resorted sandy terrace of Islamgarh stage (Middle Pleistocene, 250,000-50,000 years ago).

Each terrace is associated with one or more type(s) of sand ridges and depressions. The form and orientation of these ridges and depressions control the soil moisture and eventually the vegetation and provide the basis for their development as rangelands. Four types of sand ridges and depressions have been recognized on these terraces (FAO/ADB, 1993; Tahir et al., 1995). They are:

i) Longitudinal sand ridges,

ii) Alveolar sandy ridges,

iii) Low transverse sand ridges,

iv) High transverse sand ridges.
The longitudinal sand ridges are found within the first and the lowest terrace of Halizabad stage, the alveolar sand ridges and low transverse sand ridges are confined to the second intermediate terrace of Wazirabad stage whereas the high transverse sand ridges are connected with the third, the highest and the oldest terrace of Islamgarh stage.

In addition to the above mentioned physiographic units courses of old abandoned river occur in patches as covered channel remnants throughout the wind resorted sandy desert. These channel remnants are 3 to 10 meters below the general level of surrounding landscape and are 1.5 to 5 kilometers wide (Tahir et al., 1995).

The soil of the wind resorted sandy desert are predominantly sandy ranging in texture from sand to sandy loam, although small proportion of loam soils are also found. In addition, some clayey soils occur as small scattered patches. The ridges are invariably made up of sands. The windward faces of the ridges contain stabilized sands, whereas the leeward faces and the crest carry shifting sands and semi-stabilized sands respectively. The inter ridge depressions contain soils ranging in texture from loamy sand through sandy loam parts of the depressions are occupied by loam and the intermediate parts by sandy loam.

All the soils are brown in colour, deeply homogenized with gradual gradation of colour and texture, which become lighter with depth. The soils are moderately to strongly calcareous containing very few fine to common, fine to medium scattered lime nodules in the profile but without a definite zone of lime accumulation (Mohammad, 1985; 1989). All the soils are non-saline and non-sodic with pH values ranging between 8.2 to 8.4 (Baig et al., 1975).
7b.4 Range management units

For convenience of elevation for rangeland, desert margins (Lesser Cholistan) and wind resorted sandy desert (Greater Cholistan) are further grouped into the following five range management units based on similar potential for development (Baig et al., 1980; Kazmi and Ahmad, 2000). The units are (figure 28):

- 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, soil, vegetation, main constraints and development improvement possibilities of each management unit is given below:

7b.4.1 Range management unit 1

Patches of moderate sized old channel remnants occur through the sandy desert of Cholistan and occupy an overall area of 39,500 ha (table 26).

These channels mark the drainage lines of the Late Pleistocene period filled with Late Pleistocene river alluvium. Shifting of low sandy hummocks later covered them.

The predominant soil in this unit is sandy loam having moderate water-holding capacity. Small patches of loamy and clayey soil also occur locally. At places the soil is underlain by cemented lime 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 the area are therefore, relatively better than those of the surrounding landscapes. Due to the favourable conditions of recharge, the quality of the groundwater is expected to be good, especially of the upper lenses.

Table – 26

<table>
<thead>
<tr>
<th>Mega Regions</th>
<th>Range Units</th>
<th>Extent (Hec.)</th>
<th>Percentage</th>
<th>Existing grasses, shrubs and forbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater Cholistan: Wind resorted sandy terraces</td>
<td>1. Old channel beds</td>
<td>39,500</td>
<td>1.5</td>
<td>Eleusine compressa, Cenchrus ciliaris, Haloxylon salicormicum, Corchorus depressus, Euphorbia thymifolia and Prosopis spicigera.</td>
</tr>
<tr>
<td></td>
<td>2. Honey combed ridge system</td>
<td>469,500</td>
<td>18.0</td>
<td>Calligonum polygonoides, Tribulus terrestris, Eleusine compressa, Haloxylon salicormicum, Cenchrus ciliaris, Lasiurus hirsutus, Corchorus depressus and Euphorbia thymifolia.</td>
</tr>
<tr>
<td></td>
<td>3. Linear ridge system</td>
<td>859,800</td>
<td>33.0</td>
<td>Calligonum polygonoides, Dipterygium glaucum, Haloxylon salicormicum, Tribulus terrestris, Eleusine compressa, Cymbopogon jasuticus, Lepidium pyrotechnicum, Acca javanica, Aristida depressa, Corchorus depressus, Lasiurus hirsutus, Prosopis spicigera and Cupanias deciduas.</td>
</tr>
<tr>
<td>Lesser Cholistan: Wind resorted dissected terrace remnants</td>
<td>4. Moving sand dunes</td>
<td>1,005,000</td>
<td>38.5</td>
<td>Calligonum polygonoides and Haloxylon salicormicum.</td>
</tr>
<tr>
<td></td>
<td>5. Saline belts</td>
<td>233,000</td>
<td>9.0</td>
<td>Haloxylon recurvum, Suaeda frutescens, Salsola portulaca and Tamarix gallica.</td>
</tr>
</tbody>
</table>


The present vegetation includes a mixture of grasses, shrubs and forbs. Among the grasses *Eleusine compressa* and *Cenchrus ciliaris*; among the shrubs, *Haloxylon salicormicum* 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. Reseeding of grasses like Cantharus ciliaris and Lasiorus hirsutus could make improvements in forage production and growing annual legumes such as Medicago hispida, planting forage trees like Ziziphus jujuba around the watering points (tobas) and adopting planned rotational grazing (Baig et al., 1980). Further increase in forage/fodder production could be achieved by cultivating patches of the unit where both soil and groundwater resources allow, for supplementary fodder. Installing small-size transportable tube-wells at suitable places could develop more watering points. Possibilities for installing windmills are to be explored.

7b.4.2 Range management unit 2

This unit occurs in patches 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 469,500 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 that 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 honey combed system.

This system contains 65 percent rolling sand ridges, 35 percent enclosed level to nearly level inter ridges depressions. The windward faces of the ridges have stabilized sand whereas the slip faces of the ridges have shifting sand. The depressions contain loamy sand towards the base of the windward faces of sand ridges and sandy loam in the lowest part. Loamy sand soil is excessively drained and have a low water holding capacity. Sandy loam soil occupying run-on positions, have moderate water holding capacity.

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

The sandy soil of this unit with rolling relief form is 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, Cenchrus ciliaris, Losinurus hirsutus and some forbs like Corchorus depressus and Euphoriba thymifolia grow in depressions.
As against the soil on the un-favourable relief of this unit, the soil of depressions have a potential for increased forage production by reseeding of grasses such as *Cenchrus ciliaris* and *Lasiurus hirsutus* as was practiced on similar areas in India (Baig et al., 1980; FAO/ADB, 1993) with a rainfall of 125-200 mm. Small doses of slowly soluble phosphate fertilizer may be tried to stimulate early growth. Cutting of plantation of *Calligonum polygonoides* and *Tamarix articulata* on sand ridges may also be helpful to increase forage production as well as sand stabilization.

**7b.4.3 Range management unit 3**

This unit is composed of transverse and longitudinal sand ridge system covering an area of about 859,000 ha. The transverse sand ridges consists of two types depending upon their height and breadth. According 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 meters (Tahir et al., 1995) 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 meters and as wide as 60-90 meters. 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 windward slopes of the ridges are gentle whereas the leeward faces are very steep. 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-NF direction. The ridges are 3-5 meters high, 30-45 meters wide with gentle slope on the windward slide and steep slope on the leeward faces. The ridges and inter ridge depressions occupy 60 percent and 40 percent of the area 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
Rann of Kutch, the low transverse and longitudinal sand ridges have developed
mainly from the river alluvium.

The soil on stabilized windward faces of all the sand ridges are brown, deeply
homogenized, moderately calcareous fine sands containing very few to common
line to medium lime nodules in the soil and on the surface. The crest and leeward
faces contain moderately calcareous, semi-stabilized and shifting sands
respectively with grayish colour and without lime nodules. The soil is brown/dark
brown in colour and is deeply homogenized with weak coarse sub-angular blocky
structure in the subsoil. The loamy sand soil is excessively drained and have low
water-holding capacity, whereas the sandy loam and loam soil is 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 of shrubs, grasses and forbs of low
nutritional value. The dominant species are Calligonum polygonoides, Dipterygium
glancum, Haloxylon salicornicum, Tribulus terrestris and, Eleusine compressa.
Next in importance are Cymbopogon jawaranensia, Leptadenia pyrotechnica,
Aerva javanica 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 Lasius hirsutus are also found both
in the depressions and on the stabilized ridges. Some trees of Prosopispicigera
and Capparis decidua also grow in the depressions. Locally Prosopispicigera is
also seen on the leeward faces of some ridges, including that the ridges have
moved to cover part of the area in the depressions which is 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 proper forage, even these unpalatable species are browsed of necessity of the livestock, only camel and goats, are 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. Cutting of plantation of *Calligonum polygonoides* and *Tamarix articulata* on sand ridges may also be helpful to increase forage production as well as sand stabilization. Reseeding of native grasses like *Cenchrus ciliaris* and *Lasianthus hirsutus* with small application of phosphate fertilizer may be tried on run-on sites in the depressions (Baig et al., 1980).

**7b.4.4 Range management unit 4**

This unit occurs in patches in the desert margin (Lesser Cholistan) and covers about 1,005,000 ha. It includes mainly undulating to rolling sand dunes and narrow inter-dunal depressions. The dunes and depressions contain sand and loamy sand respectively. A locally minor patch of sandy loam soil is also encountered in some depressions. The soil 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 soil as well as the adjacent irrigated agricultural lands. The present vegetation cover which is very sparse comprises mainly Calligonum polygonoides and Haloxyton salicornium 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 the 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 (Baig et al., 1980). Reseeding of grasses in this unit does not seem feasible, due to the danger of burial of seedlings by moving sand as well as the lack of sizeable patches of good depressional soil.

7b.4.5 Range management unit 5

This unit occurs in desert margin (Lesser Cholistan) and comprises saline alluvial flats making the sub-recent filled-in channels of Hakra River and covering an area 233,000 ha. The soil in the alluvial flats is predominantly brown dark/dark brown clay and silty clay which is homogenized to moderate depths and have a weak coarse sub-angular blocky structure in subsoil. They are moderately calcareous and severely saline or saline-sodic.

This soil occurring in the saline alluvial belts are mainly barren. Locally, however, a sparse cover of xeromorphic halophytic plant species like Haloxyton reouryum.
Sueda fruticosa, Salvola loetida and Tamarix gallica are found (Baig et al., 1980). 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 fulfill 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 (FAO/ADB, 1993).

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

7b.5 Discussion

Mega Land Systems (Lesser and Greater Cholistan) have been split into eight Macro Land Systems based on geomorphology as it controls soils, moisture and eventually vegetation – an important component of range ecosystem, upon which pastoralism depend. Land system (figure 29) I has the best potential for irrigation. Biomass production varies between 300 to 500 Kg/ha and is not particularly well suited for livestock intensification.
Land system (table 27) 2, 3, 4, and 8 are all suited for rangeland enhancement and livestock intensification.

Land system 5, 6, and 7 are not suited for livestock production. The total biomass production being from 120 to 350 Kg/ha. These areas could be usable for wildlife conservation if well equipped with windmills and drinking troughs.

Table – 27

<table>
<thead>
<tr>
<th>LAND SYSTEM</th>
<th>MACRO</th>
<th>Extent (Hec.)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesser Cholistan: Wind eroded dissected terrace remnants</td>
<td>Flats with sandy terrace remnants</td>
<td>826100</td>
<td>31.7</td>
</tr>
<tr>
<td></td>
<td>Sandy terrace remnants with some flats</td>
<td>411700</td>
<td>15.8</td>
</tr>
<tr>
<td>Greater Cholistan: Wind resorted sandy terraces</td>
<td>Low sand dunes and hollows</td>
<td>398700</td>
<td>15.3</td>
</tr>
<tr>
<td></td>
<td>Longitudinal ridges and valleys</td>
<td>167000</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>Low transverse ridges and valleys</td>
<td>18200</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Alveolar ridges and valleys</td>
<td>398700</td>
<td>15.3</td>
</tr>
<tr>
<td></td>
<td>High transverse ridges and valleys</td>
<td>338700</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>Partly covered channels</td>
<td>46900</td>
<td>1.8</td>
</tr>
</tbody>
</table>


Land System terminology applied in this study is synonymous to that of the agro-ecological zone, presented in National Conservation Strategy (Government of Pakistan and IUCN, 1992), which is commonly used at the national level. The use of Land System terminology is well established worldwide and in Pakistan. Land System map for Cholistan is compiled from the integration of information on climate, geomorphology, soil, wind erosion, and vegetation. The units delineated on the map are biophysically homogeneous and versatile and such can be used confidently for land use planning of crops, range/livestock, irrigation, and road alignment.
The Land System approach is because of its efficiency in guiding sustainable land use and natural resource management using maximum benefits of natural quality and quantity, with minimum inputs applied and without damaging the resource base.

7b.6 Conclusion

It has been conceived that topographic form is the main factor playing a vital role towards the development of Cholistan desert as rangelands. Various relief positions control the occurrence of soils, and availability of moisture for the vegetation growth. For example in the southern region (Greater Cholistan), ridges invariably contain sands which have very low water holding capacity while the inter-ridge depression or old channel beds contain loamy sands, sandy loam or loam which have good water holding capacity. The type of depression also plays an important role in rangeland development. The old Hakra bed acts as drainage ways of the area and collects most of the runoff. Soil of such channel bed is mostly sandy loam having moderate water holding capacity. Thus, the availability of moisture in the channel is more and capable of supporting grasses and legumes as a supplementary fodder. This area is suitable for cattle raising due to its favourable relief and availability of drinking water.
CHAPTER 7c

LEPTOCHLOA FUSCA: A HIGH YIELDING CANDIDATE GRASS FOR UTILIZATION OF SALT-AFFECTED SOIL AND WATER RESOURCES IN CHOLISTAN

7c.1 Overview

In Cholistan desert, about 0.44 million hectares are salt-affected low-lying and clayey in nature, locally known as "dhars", where rainwater as well as saline groundwater could be utilized for growing salt grasses like Leptochloa fusca "kalar grass" as forage during summer. L. fusca is a promising candidate grass for economic utilization and better management of sodic, high pH (soluble ions), saline soil and saline water resources of Cholistan desert. L. fusca is known to be a versatile, halophytic, primary colonizer, easily propagatable, perennial, nutritive and palatable forage plant species. The grass has the good biomass producing potential and can grow equally well both under upland and submerged saline soil environment.

7c.2 Introduction

Total area of Cholistan desert is about 2.6 million hectares, out of which 1.13 million ha comprising stable as well as non-stable sand dunes, 0.95 and 0.06 million ha consist of sandy and loamy soils respectively, while 0.44 million ha are clayey in nature, locally known as "dhars". About 17% of Cholistan consist of such "dhars" (table 28) having flat and hard surface with salt incrustation and surrounded by sand dunes. Dhars are shallow to moderately deep, poorly drained with low vegetation, calcareous and having saline sodic fine to medium textured
clayey soils. Except, *Haloxylon recurvum* (non-palatable) no other plant specie can survive due to salinity, compaction of soil and complete inundation during rainy season. The ponded rainwater in “dhars” stagnates for a period until the water evaporates (Khan et al., 1990). It is judicious to utilize the land by using ground saline and surface rainwater resources for growing palatable grasses. Biological approach for economic utilization of salt-affected soil is feasible and is the only viable method when the soil is sodic and sweet water is not available for irrigation.

*Leptochloa fusca* is high tolerant to saline and sodic conditions even irrigated by saline groundwater or ponded rainwater. After the successful cultivation of *L. fusca* in Cholistan, other palatable grasses like para grass (*Brachiaria mutica*), Rhodes grass (*Chloris gayana*), Bermuda grass (*Cynodon dactylon*) and *Sporobolus* grass species can be tested. The cultivation of salt tolerant grasses would not only provide much needed palatable forage for livestock but also improve the physical properties of the soil due to biological activity of grass roots.

**Table – 28**

<table>
<thead>
<tr>
<th>Soil Types</th>
<th>Extent (Hect.)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand dunes</td>
<td>1,133,900</td>
<td>44.0</td>
</tr>
<tr>
<td>Sandy soils</td>
<td>945,500</td>
<td>37.0</td>
</tr>
<tr>
<td>Leamy soils</td>
<td>58,700</td>
<td>2.0</td>
</tr>
<tr>
<td>Saline sodic clayey soils (Dhars)</td>
<td>441,900</td>
<td>17.0</td>
</tr>
<tr>
<td>Total</td>
<td>2,580,000</td>
<td>100.0</td>
</tr>
</tbody>
</table>


7c.3  Growth characteristics of *Leptochloa fusca*

*Leptochloa fusca* is also known as *Diplochne fusca*, widely spread in salt affected regions of Pakistan. This forage plant is locally known as “Kalar grass” (salt grass). Being a grass of tropical climate, the plant follows the photosynthetic CO₂
fixation process of C₄-NAD-malic enzyme metabolism (Zafar and Malik, 1984). It is native of saline soil which gives clear indication of its halophytic character, the plant is perennial or biennial in nature. It has been regarded as good quality forage especially in salt-affected and waterlogged areas where other superior forage species may not grow successfully.

*Leptochloa fusca* can be easily propagated and established through seed, stem cutting, root stumps or rhizomes. The grass can grow to a height of 1 to 1.5 meters with a high leaf production rate and can be grazed directly or cut for stall-feeding. This fodder appears highly palatable to sheep, goats, buffaloes and cattle alike and no toxic effects of this grass during long-term consumption have been diagnosed. Moreover, it is similar to other conventional fodder regarding its nutritional status and 3-4 cutting within 3 months may be easily harvested, producing 20-40 tons of green fodder per ha per year or 5-10 tons per ha per cutting in salt-affected soils (Sandhu *et al.*, 1981; Qureshi *et al.*, 1982; Sandhu, 1993). The grass grows well during the hot season from March to September with peak yields during rainy season i.e. July and August in Pakistan, indicating a strongly thermophilic character. The development of extensive and dense fibrous root system has been observed even in highly sodic soils (Joshi *et al.*, 1981). The penetration of roots in such soils can enhance hydraulic conductivity, microbial activity, organic matter and ultimately leaching of salts. This grass can make better growth under normal situation than under stress conditions, but it is a common observation that, in normal soils, the grass could not compete with other species and soon eliminated due to growth of other vegetation. Joshi (1981) noted a decline of *L. fusca* growth due to decrease of soil sodicity, while Haq and Khan (1971) observed that *L. fusca* has a general tendency to decrease ECₑ (electrolyte conductivity), SAR (sodium adsorption ratio), pH (soluble ions) and even ESP (exchangeable sodium
percentage) of artificially salinized soils. Malik (1986) confirmed the utility of *L. fusca* not only as a primary colonizer of salt-affected lands but also as ameliorative plant for the soil.

### 7c.4 Nutritional requirements

It has been observed that 3-4 cuttings of this grass could be easily taken without the addition of nitrogen (N) fertilizer in salt-affected and less fertile soils. Malik (1980) demonstrated a high activity of nitrogen, which indicates strong associative symbiotic relationship of N\(_2\) - fixing bacterium (Bacillus gram negative) in the rhizosphere of *L. fusca*. Moreover, the nitrogen fixation through the growth of blue green algae and *Azolla* under flooded conditions may partly contribute to the nitrogen supply and economy of the specie. It is also observed that *L. fusca* contribute more stable organic matter fraction due to its slow decomposition as compared to succulent plant specie like *Sesbania cuneata*. Kumar (1980) reported an abrupt increase in the yield of *L. fusca* from 24-26 tons per ha. per year, without N application to 41-46 tons per ha per year when only 40 Kg N per ha was applied in a sodic soil. Abdullah (1985) showed a definite ameliorative effect of phosphorus (P) on the growth of *L. fusca* under saline environment. The application of P at the rate of 50 Kg per ha gave significantly higher fresh and dry matter yield at EC\(_e\) 10 dS m\(^{-1}\) than all other treatments, which was followed by 75 and 25 Kg P per ha at EC\(_e\) 20 dS m\(^{-1}\). The synergistic P × salinity effect was obvious at the highest P level of 75 Kg per ha. Thus, the specie is responded favourably to P application at all salinity levels studied i.e. EC\(_e\) 3.5 to 30 dS m\(^{-1}\), indicating higher P requirements. In general, the specie is capable to accumulate trace elements (Zn, Cu, Fe, Mn) in a sufficient amount to meet the dietary requirements of the livestock under saline soil conditions.
7c.5 Role in soil reclamation

*Leptochloa fusca* behaved as a typical Cryptno-eu-halophyte having both accumulating and excreting properties. The efficient salt excretion from the shoot makes it a useful plant to deplete excessive salt from the root-zone and to provide the better root-environment for the growth of other plants. The extensive and fibrous roots of grass can open soil, increase air exchange, organic matter and hydraulic conductivity, decrease rhizosphere pH, stimulate biological activities, dissolve native CaCO₃, enhance leaching of salts, lower the water table of waterlogged soils, release plant nutrients and the shoot foliage can increase organic matter, humus and soil mulching. Decrease surface evaporation and improve physical properties of soil with the passage of time (Haq and Khan 1971; Joshi et al., 1981; Abdullah et al., 1986; Malik et al., 1986 and Akhtar et al., 1988).

7c.6 Use of ground saline water for irrigation

Although the groundwater is saline but it can be used for saline agriculture to grow salt tolerant trees, vegetables, crops and fodder grasses in non-saline-non-sodic coarse textured soils with minimum adverse effects due to rapid leaching of salts beyond the root zone and flushing of salts from root zone by rains. Furthermore, dense saline-sodic soils can also be used for growing such palatable grasses, which are very salt tolerant and capable of surviving in soils having poor properties. The sandy and loamy soil that is about 1 million hectares can be brought under agriculture by using underground saline water and harvested rainwater. Experiments showed that under certain conditions plant could not only survive but also even vast area of land could be irrigated with water of such high concentration. The soil is either sandy gravel or dune sand. Moderately saline irrigation water stimulates vegetation, assists the benevolent bacteria of the soil
and improves yield and quality. Further, use of brackish water reduces soil evaporation, transpiration of plants and increases resistance to drought (Abdullah et al., 1990; 1991). The solution of the adverse effect are suggested:

- Identification and selection of species and varieties tolerant of high salinity,
- The use of brackish water of such a degree of salinity only as is compatible with help of such species and with the nature of the soil,
- The selection of irrigation with such water in areas in which soils permeable, well drained and rich in calcium and the hydrates of iron and aluminium.

Pakistan Council of Research in Water Resources (PCRWR) has planted *Eucalyptus, Acacia, Parkinsonia, Zizyphus* (Beri), *Tamarix, Prosopis, Asparagus*, Date palm, Pomegranate, Jojoba and Iple Iple (*Leucaena leucocephala*). The saline water of concentration TSS (total soluble salts) 2800 ppm (part per million) and SAR (sodium adsorption ratio) 14 is being used for irrigation alongwith harvested rainwater to flush the salts at certain intervals. The calcium sulphate fertilizer is also used to neutral the adverse effects of sodium salts. The growth of some of them is given in tables 29, 30 and 31.

### Table - 29

**BIOMASS OF FODDER GRASSES PER HECTARE GROWN AT DINGARIH, CHOLISTAN DESERT BY USING SALINE WATER**

<table>
<thead>
<tr>
<th>Fodder grass</th>
<th>Biomass Fresh (Kg)</th>
<th>Biomass Dry (Kg)</th>
<th>Carrying capacity per year</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cenchrus ciliaris</em></td>
<td>16811</td>
<td>15012</td>
<td>Camel: 2, Goat: 14, Sheep: 16, Cattle: 3</td>
</tr>
<tr>
<td><em>Panicum antidotale</em></td>
<td>22191</td>
<td>12407</td>
<td>Camel: 1, Goat: 11, Sheep: 14, Cattle: 3</td>
</tr>
<tr>
<td><em>Lavina simbius</em></td>
<td>25217</td>
<td>18247</td>
<td>Camel: 2, Goat: 17, Sheep: 20, Cattle: 4</td>
</tr>
<tr>
<td><em>Napier Bajra</em></td>
<td>43710</td>
<td>38789</td>
<td>Camel: 4, Goat: 35, Sheep: 42, Cattle: 9</td>
</tr>
<tr>
<td><em>L. fusa</em></td>
<td>13449</td>
<td>14445</td>
<td>Camel: 1, Goat: 10, Sheep: 13, Cattle: 3</td>
</tr>
</tbody>
</table>

**Forage requirement**

- Dry matter per day:
  - 1 sheep - 2.5 Kg.
  - 1 goat - 3.0 Kg.
  - 1 camel - 25.0 Kg.
  - 1 cattle - 12.5 Kg.

**Source:** Based on field survey; June 2000.
Table - 30

BIOMASS POTENTIAL OF SOME SALT TOLERANT FORAGES

<table>
<thead>
<tr>
<th>Species code</th>
<th>Species</th>
<th>Green matter (Kg/plant)</th>
<th>Dry matter (Kg/plant)</th>
<th>Green matter yield (tons/hec)</th>
<th>Dry matter yield (tons/hec)</th>
<th>Plants/hec</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Atriplex amnicola 949</td>
<td>4.31</td>
<td>1.99</td>
<td>2.7</td>
<td>1.24</td>
<td>625</td>
</tr>
<tr>
<td>2</td>
<td>Atriplex amnicola 971</td>
<td>5.37</td>
<td>2.39</td>
<td>3.4</td>
<td>1.49</td>
<td>625</td>
</tr>
<tr>
<td>3</td>
<td>Atriplex amnicola 573</td>
<td>6.73</td>
<td>3.42</td>
<td>4.2</td>
<td>2.14</td>
<td>625</td>
</tr>
<tr>
<td>4</td>
<td>Atriplex amnicola × Atriplex montanaria</td>
<td>5.17</td>
<td>2.15</td>
<td>3.2</td>
<td>1.34</td>
<td>625</td>
</tr>
<tr>
<td>5</td>
<td>Atriplex hutchinsiana 1208 (Camarvan)</td>
<td>3.11</td>
<td>1.6</td>
<td>7.8</td>
<td>4.0</td>
<td>2500</td>
</tr>
<tr>
<td>6</td>
<td>Atriplex hutchinsiana 1200 (Leonor)</td>
<td>2.0</td>
<td>1.2</td>
<td>5.0</td>
<td>3.0</td>
<td>2500</td>
</tr>
<tr>
<td>7</td>
<td>Atriplex cinerea 524</td>
<td>5.0</td>
<td>2.35</td>
<td>3.1</td>
<td>1.46</td>
<td>625</td>
</tr>
<tr>
<td>8</td>
<td>Atriplex kantooratus</td>
<td>5.45</td>
<td>3.19</td>
<td>3.4</td>
<td>2.9</td>
<td>625</td>
</tr>
<tr>
<td>17</td>
<td>Maireana gypsea 1062</td>
<td>2.55</td>
<td>1.2</td>
<td>6.3</td>
<td>3.0</td>
<td>2500</td>
</tr>
</tbody>
</table>

Source: PADMU - Pakistan Desertification Monitoring Unit.

---

Table - 31

SURVIVAL PERCENTAGE AND CANOPY COVER OF SOME PLANTS GROWN IN CHOLISTAN DESERT

<table>
<thead>
<tr>
<th>Name of Tree / Shrub / Bush</th>
<th>Age (months)</th>
<th>Survival Percentage</th>
<th>Height (Cm)</th>
<th>Canopy Cover (Cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min.</td>
<td>Mean</td>
</tr>
<tr>
<td>Falcatir (Camelthorn)</td>
<td>24</td>
<td>76</td>
<td>90</td>
<td>156</td>
</tr>
<tr>
<td>Tamarix</td>
<td>24</td>
<td>42</td>
<td>59</td>
<td>106</td>
</tr>
<tr>
<td>Acacia</td>
<td>24</td>
<td>67</td>
<td>66</td>
<td>125</td>
</tr>
<tr>
<td>Beri (Zizyphus)</td>
<td>34</td>
<td>45</td>
<td>55</td>
<td>118</td>
</tr>
<tr>
<td>Juqinta (Simmondsia Chinensis)</td>
<td>18</td>
<td>76</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>Atriplex hutchinsiana (Local)</td>
<td>11</td>
<td>65</td>
<td>--</td>
<td>77</td>
</tr>
<tr>
<td>Atriplex amnicola 573</td>
<td>11</td>
<td>40</td>
<td>--</td>
<td>48</td>
</tr>
<tr>
<td>Atriplex amnicola 197</td>
<td>11</td>
<td>80</td>
<td>--</td>
<td>74</td>
</tr>
<tr>
<td>Atriplex amnicola 223</td>
<td>11</td>
<td>25</td>
<td>--</td>
<td>47</td>
</tr>
<tr>
<td>Atriplex hutchinsiana 1041</td>
<td>11</td>
<td>60</td>
<td>--</td>
<td>51</td>
</tr>
<tr>
<td>Atriplex hutchinsiana 1036</td>
<td>11</td>
<td>70</td>
<td>--</td>
<td>66</td>
</tr>
<tr>
<td>Atriplex cinerea</td>
<td>11</td>
<td>40</td>
<td>--</td>
<td>28</td>
</tr>
<tr>
<td>Atriplex kantooratus</td>
<td>11</td>
<td>60</td>
<td>--</td>
<td>76</td>
</tr>
<tr>
<td>Atriplex commerical</td>
<td>11</td>
<td>25</td>
<td>--</td>
<td>44</td>
</tr>
<tr>
<td>Maireana gypsea</td>
<td>11</td>
<td>85</td>
<td>--</td>
<td>35</td>
</tr>
</tbody>
</table>

Source: PADMU - Pakistan Desertification Monitoring Unit.
The germination capacity of different varieties of tomato, ladyfinger (*bhindi*), spinach (*palak*), cowpea and zucchini (*turi*) at different levels ECₑ 3 to 18 mho/cm was studied in sand culture (PADMU, 1986). The germination was delayed and decreased with the increase in salinity. Significant vegetables were found to fall in the order of salt tolerance: Spinach > Zucchini > Cowpea > Tomato > Ladyfinger. List of some salt tolerant grasses and forages cultivated in Cholistan desert by using saline water is given in Table 32.

<table>
<thead>
<tr>
<th>Forage Crop/Grass/Bush</th>
<th>Tolerance (ECₑ×10⁻⁴)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkali grass (<em>Puccinellia arioides</em>)</td>
<td>High</td>
</tr>
<tr>
<td>Bermuda grass (<em>Cynodon dactylon</em>)</td>
<td>High</td>
</tr>
<tr>
<td>Kallar grass (<em>Leptochloa fusca</em>)</td>
<td>High</td>
</tr>
<tr>
<td>Salt grass (<em>Distichlis stricta</em>)</td>
<td>High</td>
</tr>
<tr>
<td>Desert wheat grass (<em>Atriplex cristatula</em>)</td>
<td>High</td>
</tr>
<tr>
<td>Barley (<em>Hordeum vulgare</em>)</td>
<td>High</td>
</tr>
<tr>
<td>Rape (<em>Brassica napus</em>)</td>
<td>Medium</td>
</tr>
<tr>
<td>Clover (<em>Melilotus</em>)</td>
<td>Medium</td>
</tr>
<tr>
<td>Alfalfa (<em>California common</em>)</td>
<td>Medium</td>
</tr>
<tr>
<td>Oats (<em>Avena</em>)</td>
<td>Medium</td>
</tr>
<tr>
<td><em>Atriplex</em> spp.</td>
<td>High</td>
</tr>
</tbody>
</table>

Source: PADMU – Pakistan Desertification Monitoring Unit.

### 7c.7 Conclusion

The growth factors such as easy propagation, high spreading rate, colonizing ability, vigorous growth, yield, palatability, nutritional value, long term survival and high adaptability to environmental stress make *L. fusca* an excellent and versatile specie that can be cultivated by using brackish water and salt-affected land of Cholistan for economical exploitation. The specie has great promise for the economic utilization of sodic, high pH, waterlogged and saline soils. Similarly, high saline-sodic water can be used for successful cultivation of *L. fusca*. 
CHAPTER – 7d

ADAPTATION OF AUSTRALIAN FORAGE SHRUBS IN CHOLISTAN

7d.1 Overview

The study of adaptation of Australian shrubs took place to introduce a number of new high yielding winter growing halophytic forages *Atriplex* and *Maireana* species. The plants were grown in a field consisting of fine sandy, sandy loam and clay loam soils at 4x4 meter spacing by using saline groundwater (EC_e=4.9 dS m\(^{-1}\)) and surface rainwater (EC_e=0.607 dS m\(^{-1}\), RSC=6.87). It was recorded that out of cultivated 13 *Atriplex* and 10 *Maireana* species, only 11 *Atriplex* and 7 *Maireana* species survived in Cholistan desert. Overall, the *Atriplex* species showed better performance and adaptation in respect of establishment, survival, growth, bush formation and total foliage compared to *Maireana* species.

7d.2 Introduction

The native palatable forage plant species in Cholistan desert are vanishing and the rangelands are going to be deteriorated due to overgrazing. The winter season is usually remaining dry as much amount of rainfall received during summer season and rangelands are expected to supply enough grazing for the livestock from July to October. Moreover, in the winter season, the existing native forage species dried up, become dormant or cease their normal growth due to abrupt fall of temperature and consequent frost action especially during winter nights.

The soils of Cholistan is suitable for growing *Atriplex* (salt bushes) and *Maireana* (blue bushes) species in sand dune, sandy, loamy sand, sandy loam to loamy fine
sand because these bushes are considered sensitive to waterlogged or ponded water conditions. The soil of Cholistan is low to excessively drained, coarse textured derived from aeolian material mainly deposited by winds and brought from the Rann of Kutch and sea coast. About 80% of the Cholistan consist of such soils. Usually very fine sandy to coarse textured soils are severely affected by wind erosion (Akram and Abdullah, 1990).

The *Atriplex* and *Maireana* species are quite tolerant to low temperature, cease growth during high temperature and flourish well in cool season (BOSTID, 1975; 1990; Qureshi, 1993 and Ahmad & Ismail, 1995). During winter season, it is easy to regularize the normal supply of irrigation water and almost impossible during hot summers (Khan *et al.*, 1990). New forage species, which could be grown on desertified soil by using ground saline water can contribute a lot in supplementing existing forage resources to the whole economy of desert population entirely depend on their livestock. Thus, growing salt and blue bushes will not only provide the much needed palatable forages for the livestock but also improve the soil physical properties and stabilize the sandy soils against wind erosion. The 100-200 mm annual rainfall and ground saline water (*E.C.* =4-30 dS m⁻¹) resources of desert can also be utilized for biomass production, improving the rangelands and better livestock production. Moreover, the forage supply could be regularized during winter season and the migration of livestock towards irrigated areas due to fodder shortage would be decreased. The *Atriplex* and *Maireana* species are new cultivars and even the preliminary findings *i.e.* seed germination, propagation, establishment, survival, tolerance and adaptation under different soils salinity regimes, ecosystems, screening, palatability, biomass yields and economic outputs are yet to be investigated at laboratory, research station and farmer’s field level. However, such salt and blue bushes can prove promising economic value forage
plants for better exploitation and utilization of salt-affected soil and water resources. The adaptation study on *Atriplex* and *Maireana* species under actual desert environment in Cholistan desert is pioneer one in Pakistan and will provide basic infrastructure to initiate such trials in other deserts of Pakistan. In this way the huge soil and ground saline water resources lying waste could be converted into profitable and productive halophytic rangeland system.

The adaptation trial on a number of *Atriplex* and *Maireana* species was executed at the desert field research station, Dingarh, Cholistan. Specific information about the experimental site regarding climate, soil characteristics, frequency of irrigation, water table, groundwater salinity are highlighted in tables 33, 34 and 35 whereas the total number of halophytic species included in trial are given in table 36. The following steps were taken during the adaptation trial conducted by PCRWR.
### Table - 33

**SITE SPECIFIC INFORMATION OF DESERT FIELD RESEARCH
STATION DINGARII, CHOLISTAN DESERT**

<table>
<thead>
<tr>
<th>Site name:</th>
<th>Desert Field Research Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location:</td>
<td>Dingarh, Cholistan, Bahawalpur (Pakistan).</td>
</tr>
<tr>
<td>Elevation:</td>
<td>350 feet a.s.l. Latitude = 28°-57', Longitude = 71°-50'</td>
</tr>
<tr>
<td>Temperature:</td>
<td>Mean annual 26.6° C. Mean summer 33.41 °C, Mean winter 19.5° C. Maximum 51° C. Minimum –2° C.</td>
</tr>
<tr>
<td>Rainfall:</td>
<td>Mean annual 100-200 mm. Mostly received = July, August and September. Least received = winter.</td>
</tr>
<tr>
<td>Relative humidity:</td>
<td>Mean annual 64.87%. Mean summer (1700 hours PST) 29.41%, Mean winter (1700 hours PST) 35.7%.</td>
</tr>
<tr>
<td>Wind speed:</td>
<td>Mean summer 7 – 15 Km/hr; Mean winter 2 – 7 Km/hr.</td>
</tr>
<tr>
<td>Soil type:</td>
<td>Fine sand, Loamy sand, Sandy loam, Clay loam, Silty clay.</td>
</tr>
<tr>
<td>Live stock:</td>
<td>Sheep, goat, cattle, camel, and donkey.</td>
</tr>
<tr>
<td>Major Native Plant Species:</td>
<td></td>
</tr>
<tr>
<td>Trees:</td>
<td>Acacia nilotica (Kikar or Babul), Prosopis cineraria (Jandi), Tamarix aphylla (Frash), Zizyphus jujuba (Beri), Capparis decidua (Karir).</td>
</tr>
<tr>
<td>Shrubs:</td>
<td>Calligonum polygonoides (Phaq), Calotropis procera (Ak), Haloxylon salicornicum (Lana), Haloxylon recurvum (Khar), Leptadenia pyrotechnica (Khip), Salvola fontida (Kali-lani), Aerva pseudirientosa (Bui), Aerva pusica (Bui), Alhagi maurorum (Sawan), Crotalaria burhia (Chag), Dipteryxylon glaucum (Fehl), and Fagonia cretica (Dhamasa or Dhaman).</td>
</tr>
<tr>
<td>Grasses:</td>
<td>Aristida depressa (Lamb), Cenchrus peniciliformis (Dhanan), Cenchrus biflorus (Bhurrat), Cymbopogan jwarancua (Khai), Cyperus spp. (Deela), Eleusine flagellifera (Chimber or Ghandeel), Lasianthus sindicus (Sewan or Gorkha), Panicum antidotale (Murrat), Panicum turgifum (Murrat), Sporobolus marginatus.</td>
</tr>
<tr>
<td>Water Resources:</td>
<td>Wells and harvested rainwater reservoirs or ponds &quot;TOBAS&quot;.</td>
</tr>
</tbody>
</table>

**Source:** Based on field survey, June 2000.
<table>
<thead>
<tr>
<th>Location</th>
<th>Depth (cm)</th>
<th>Color</th>
<th>Texture (F; M; V)</th>
<th>SAR (ppm)</th>
<th>C; Mg; K</th>
<th>pH</th>
<th>(mV)</th>
<th>E.C. (mV)</th>
<th>Ce</th>
<th>%N</th>
<th>P</th>
<th>N (ppm)</th>
<th>N (ppm)</th>
<th>O.C. (mV)</th>
<th>Ce</th>
<th>%N</th>
<th>P</th>
<th>N (ppm)</th>
<th>N (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-20</td>
<td>Yellow</td>
<td>Fine sand</td>
<td>0-100</td>
<td>0-30</td>
<td>0-5</td>
<td>0-10</td>
<td>0-20</td>
<td>0-10</td>
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<td>0-100</td>
<td>0-100</td>
</tr>
<tr>
<td>2</td>
<td>30-50</td>
<td>Yellow</td>
<td>Fine sand</td>
<td>0-100</td>
<td>0-30</td>
<td>0-5</td>
<td>0-10</td>
<td>0-20</td>
<td>0-10</td>
<td>0-20</td>
<td>0-30</td>
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<td>0-100</td>
<td>0-100</td>
</tr>
<tr>
<td>3</td>
<td>60-80</td>
<td>Yellow</td>
<td>Fine sand</td>
<td>0-100</td>
<td>0-30</td>
<td>0-5</td>
<td>0-10</td>
<td>0-20</td>
<td>0-10</td>
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<td>0-10</td>
<td>0-20</td>
<td>0-30</td>
<td>0-100</td>
<td>0-100</td>
</tr>
<tr>
<td>4</td>
<td>90-120</td>
<td>Yellow</td>
<td>Fine sand</td>
<td>0-100</td>
<td>0-30</td>
<td>0-5</td>
<td>0-10</td>
<td>0-20</td>
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<td>0-10</td>
<td>0-20</td>
<td>0-30</td>
<td>0-100</td>
<td>0-100</td>
</tr>
</tbody>
</table>

**Table - 24**

**DESSERT FIELD RESEARCH STATION, CHOLISTAN DESERT**

**PHYSIO-CHEMICAL CHARACTERISTICS OF SOILS AT TRIAL SITE**
<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day</th>
<th>Interval (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1995</td>
<td>19</td>
<td>03</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>03</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>03</td>
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<td></td>
<td>30</td>
<td>05</td>
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<tr>
<td>November 1995</td>
<td>08</td>
<td>09</td>
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<td>15</td>
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<td>06</td>
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<td></td>
<td>24</td>
<td>03</td>
</tr>
<tr>
<td>December 1995</td>
<td>02</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>11</td>
</tr>
<tr>
<td>January 1996</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>February 1996</td>
<td>03</td>
<td>12</td>
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<tr>
<td>March 1996</td>
<td>12</td>
<td>37</td>
</tr>
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<td></td>
<td>23</td>
<td>11</td>
</tr>
<tr>
<td>April 1996</td>
<td>05</td>
<td>13</td>
</tr>
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<td></td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>05</td>
</tr>
<tr>
<td>May 1996</td>
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<td>18</td>
</tr>
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<td>07</td>
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<tr>
<td></td>
<td>18</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>11</td>
</tr>
<tr>
<td>July 1996</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>August 1996</td>
<td>20</td>
<td>35</td>
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<tr>
<td>September 1996</td>
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<td>31</td>
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<tr>
<td>October 1996</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>13</td>
</tr>
</tbody>
</table>

Source: PADMU - Pakistan Desertification monitoring Unit.
<table>
<thead>
<tr>
<th>Code</th>
<th>Genotypes</th>
<th>For quick germination seed enclosing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Atriplex halimus</em> (local)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><em>Atriplex annulata</em> 573</td>
<td>Gentle threshing</td>
</tr>
<tr>
<td>2</td>
<td><em>Atriplex annulata</em> 949</td>
<td>Threshing</td>
</tr>
<tr>
<td>3</td>
<td><em>Atriplex annulata</em> 971</td>
<td>Threshing</td>
</tr>
<tr>
<td>4</td>
<td><em>Atriplex humifusa</em> 1041</td>
<td>No threshing</td>
</tr>
<tr>
<td>5</td>
<td><em>Atriplex humifusa</em> 1036</td>
<td>No threshing</td>
</tr>
<tr>
<td>6</td>
<td><em>Atriplex cineria</em> 524</td>
<td>Threshing</td>
</tr>
<tr>
<td>7</td>
<td><em>Atriplex lentiformis</em></td>
<td>Threshing</td>
</tr>
<tr>
<td>11</td>
<td><em>Atriplex spp. pinifolia</em> 951</td>
<td>No threshing</td>
</tr>
<tr>
<td>12</td>
<td><em>Atriplex undulata</em> 471</td>
<td>Threshing</td>
</tr>
<tr>
<td>13</td>
<td><em>Atriplex vesicaria</em> 1056</td>
<td>Threshing</td>
</tr>
<tr>
<td>14</td>
<td><em>Atriplex commercial</em> 471</td>
<td>Threshing</td>
</tr>
<tr>
<td>15</td>
<td><em>Maireana amoena</em> 1067</td>
<td>No threshing</td>
</tr>
<tr>
<td>16</td>
<td><em>Maireana aphylla</em> 1064</td>
<td>No threshing</td>
</tr>
<tr>
<td>17</td>
<td><em>Maireana appressa</em> 1066</td>
<td>No threshing</td>
</tr>
<tr>
<td>18</td>
<td><em>Maireana brevifolia</em></td>
<td>No threshing</td>
</tr>
<tr>
<td>19</td>
<td><em>Maireana georgii</em> 1055</td>
<td>No threshing</td>
</tr>
<tr>
<td>21</td>
<td><em>Maireana polypteryxia</em> 1065</td>
<td>No threshing</td>
</tr>
<tr>
<td>22</td>
<td><em>Maireana pyramidata</em> 1050</td>
<td>No threshing</td>
</tr>
<tr>
<td>23</td>
<td><em>Maireana tomentosa</em> 1068</td>
<td>No threshing</td>
</tr>
<tr>
<td>25</td>
<td><em>Indigofera oblongifolia</em></td>
<td>No threshing</td>
</tr>
<tr>
<td>26</td>
<td><em>Atriplex stocksii</em></td>
<td>No threshing</td>
</tr>
<tr>
<td>27</td>
<td><em>Acacia ampliceps</em></td>
<td>Boil then cool water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soaking</td>
</tr>
</tbody>
</table>

Source: PADMU – Pakistan Desertiﬁcation Monitoring Unit.

7d.3 Raising of nursery

The *Atriplex* and *Maireana* species are difficult to propagate which require special techniques *i.e.* seed threshing, sowing in water permeable systems from beneath for germination, sensitive to salinity and high temperature during germination. The raising of nursery was complex and difficult process. The nursery raising was initiated during March 1995. The availability of adequate *Atriplex* and *Maireana* seedlings nursery was the fundamental factor in determining the success of the experiment. The Australian Centre for International Agricultural Research
(ACIAR) provided the seeds of 13 species of *Atriplex* and 10 species of *Maireana*. A number of *Atriplex* species seeds need to be rubbed out of the enclosed wings before sowing for easy and quick germination (table 36). The seeds of *Atriplex* were threshed/rubbed by using zero to one number glass paper, the threshed material of each species was sieved regularly to minimize the seed injuries and damage. For quick germination, unthreshed seeds and bracts were threshed and soaked in water for 12 hours. The polythene tubes (21×10 cm) were made perforated by making holes, filled with fine canal bed silt and tubes were arranged and settled firmly in rows at the bed floor prepared in depression at a place in warm semi shades position. Half of the tubes were submerged with canal water to allow water absorption into the filled soil and 2-3 seeds against each species were sown and finally covered with fine layer of silt. After completion of germination only one plant per tube was allowed to grow, regular pinching of new growth was practiced for hardening the seedlings and root development. To induce salinity tolerance, 2% NaCl solution was supplied twice during seedling growth.

7d.3.1 Transplantation

The seedling was ready in June 1995 but unable to transplant in the field due to strong and hot summer winds, high temperature and soil erosion problems. Thus, seedlings of germinated species were shifted in the desert at the advent of mild season i.e. September 1995. A site comprising small sand dunes, sandy soils and sandy loam soils was selected for growing *Atriplex* and *Maireana* forage species. The pits of about 50 centimeters deep at 4×4 meter spacing were made and each pit was half filled with canal bed silt to provide better root development environ at initial stage of plants. According to actual research plan 20 replicates of each genotype was required but the species were replicated in wide range due to variable germination and survival of seedlings of various species. The seedlings
were planted in a randomized block design one replicate of each genotype per block and planted at 4×4 meter spacing.

7d.3.2 Unknown factors

Pakistan Council of Research in Water Resources (1988) started its field activities in actual desert conditions at ‘Dingadh’ in Cholistan desert, and planted the trees of *Eucalyptus, Tamarix, Acacia* and *Zizyphus* on two hectares and gained encouraging results with slight damage by rodents (desert rats). On the basis of experience, the *Atriplex* and *Maireana* seedlings were transplanted in the field without making any prior arrangements of plant protection except bared fencing wire. It was surprising and astonishing mishap that in the first week after transplantation of *Atriplex* and *Maireana* seedlings, about 75% plants were found dead due to severe attack of termites and rodents to the rooting system. The gaps were filled with remaining seedling during October 1995 and plant protection measures were accelerated to save the bushes.

7d.4 Irrigation frequencies

Water is much expensive commodity in the deserts. It was found that about 36.1 to 48.9 cm vertical layer of sand was shifted from one place to another within 5 months (Akram and Abdullah, 1990). The required frequency of irrigation was not maintained because other plantation under different studies have to be irrigated by using the same tractor driven mobile water tanker of US 1000 gallons capacity. In addition to irrigation, the tractor was also engaged in other field operations. Nevertheless, total 42 number of irrigation in 18 months period with mean irrigation interval of 13 days were applied ranging from 3 days to 37 days interval. The rainfall of about 191 mm received in the growth period also affected the
Irrigation frequencies (table 35). The plants of each species were irrigated with saline tubewell water and rainwater depending upon the availability in the desert.

7d.5 Plants measurements

The measurements according to field record sheets of adaptation trial i.e. plant condition, plant size (height and volume), growth habit, biomass yield were recorded and compiled daily. The fresh weights of hand-prickled samples were recorded in the field after placing the samples in polythene bags by using portable balance. The fresh plant samples of 200 grams in each case except *A. vesicaria* and *M. tomentosa* (127.9 grams FW and 57.4 grams FW respectively) were oven dried at 60°C-70°C to a constant weight and the amount of water retained within tissues was estimated.

7d.6 Results

The plants of 23 genotypes varying in their inherent growth characteristics and adaptation potentials were cultivated in unattractive resource deficient desert ecosystem where plants were compelled to survive and fight a number of problems i.e. extreme aridity, nutrient deficient sandy soils, uncertain irrigation with saline water, temperature fluctuations, strong and hot summer winds, encroachment of plants by shifting sands, danger of termites, rodents and livestock etc. The data regarding cultivated, survived plants, maximum height, plant cover diameters, volume of bushes, grazeable fresh biomass, dry matter, net tissue water contents are given in tables 37 and 38.

Table – 38

BIOMASS PRODUCTIVITY AND TISSUE WATER CONTENT OF *Atriplex* AND *Maireana* BUSHES GROWN IN CHOLISTAN DESERT

<table>
<thead>
<tr>
<th>Code</th>
<th>Species name</th>
<th>Grazable fresh Biomass (g bush⁻¹)</th>
<th>FW used for DW(g)</th>
<th>DW (g)</th>
<th>Net tissue water content (g 200 g⁻¹ FW)</th>
<th>FW:DW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Atriplex halimus</em> (Local)</td>
<td>784.5</td>
<td>200</td>
<td>50.7</td>
<td>149.3</td>
<td>3.9</td>
</tr>
<tr>
<td>2</td>
<td><em>Atriplex amnicola</em> 573</td>
<td>851.0</td>
<td>200</td>
<td>54.7</td>
<td>145.3</td>
<td>3.6</td>
</tr>
<tr>
<td>3</td>
<td><em>Atriplex amnicola</em> 949</td>
<td>1472.4</td>
<td>200</td>
<td>58.1</td>
<td>141.9</td>
<td>3.4</td>
</tr>
<tr>
<td>4</td>
<td><em>Atriplex amnicola</em> 971</td>
<td>840.8</td>
<td>200</td>
<td>56.3</td>
<td>143.7</td>
<td>3.5</td>
</tr>
<tr>
<td>5</td>
<td><em>Atriplex hunburyana</em> 1041</td>
<td>910.3</td>
<td>200</td>
<td>62.0</td>
<td>138.0</td>
<td>3.2</td>
</tr>
<tr>
<td>6</td>
<td><em>Atriplex hunburyana</em> 1036</td>
<td>803.0</td>
<td>200</td>
<td>59.4</td>
<td>140.6</td>
<td>3.3</td>
</tr>
<tr>
<td>7</td>
<td><em>Atriplex cinerca</em> 524</td>
<td>1006.4</td>
<td>200</td>
<td>60.3</td>
<td>139.7</td>
<td>3.3</td>
</tr>
<tr>
<td>13</td>
<td><em>Atriplex vesicaria</em> 1056</td>
<td>139.4</td>
<td>127.9</td>
<td>34.5</td>
<td>93.4</td>
<td>3.7</td>
</tr>
<tr>
<td>14</td>
<td><em>Atriplex commercial</em> 471</td>
<td>389.5</td>
<td>200</td>
<td>54.6</td>
<td>145.4</td>
<td>3.6</td>
</tr>
<tr>
<td>15</td>
<td><em>Maireana amnicola</em> 1067</td>
<td>646.6</td>
<td>200</td>
<td>48.8</td>
<td>151.3</td>
<td>4.0</td>
</tr>
<tr>
<td>16</td>
<td><em>Maireana aphylla</em> 1064</td>
<td>323.1</td>
<td>200</td>
<td>46.7</td>
<td>153.3</td>
<td>4.2</td>
</tr>
<tr>
<td>21</td>
<td><em>Maireana polypterygia</em> 1065</td>
<td>1051.9</td>
<td>200</td>
<td>27.0</td>
<td>173.0</td>
<td>7.4</td>
</tr>
<tr>
<td>22</td>
<td><em>Maireana pyramidata</em> 1050</td>
<td>1273.3</td>
<td>200</td>
<td>31.3</td>
<td>168.7</td>
<td>6.3</td>
</tr>
<tr>
<td>23</td>
<td><em>Maireana tamentosa</em> 1068</td>
<td>69.5</td>
<td>57.4</td>
<td>10.2</td>
<td>47.2</td>
<td>5.6</td>
</tr>
</tbody>
</table>

FW = Fresh weight. DW = Dry weight

Source: PADMU – Pakistan Desertification Monitoring Unit.

7d.6.1 Species survival

The survival of various species under stress desert environment is clear indication of adaptability of respective genotype. The survival performance of *Atriplex* was observed better than *Maireana* species, only *M. aphylla* showed better plant stand (table 37). Among the *Atriplex*, even single plant of the *Atriplex* spp. *pimpinellifolia* and *A. undulata* could not survive and similar case was observed for *M. brevifolia*. The survival of *A. vesicaria*, *A. commercial*, *A. cinerea* and *A.amnicola* 971 was discouraging one (table 37). The species like *A. halimus*, *A. amnicola* 949, *A. hunburyana* 1041, *A. hunburyana* 1036 and *A. lentiformis* have shown better adaptation and survival than all other tested *Atriplex* genotypes.
7d.6.2 Height and volume of shrubs

The bush height and volume contribute major part in canopy cover especially for degraded desert soils. Overall the Atriplex gained more height and volume of bushes as compared to Maireana species. The A. lentiformis was placed at the top followed by A. bunburyana, A. commercial, A. halimus, A. cinerea and then A. amnicola. The M. amoena gained the maximum height and volume of bushes than all other Maireana species (table 37).

7d.6.3 Biomass potential

The yield potential of grazing foliage determines the quantity of forage that could be supplied by particular Atriplex and Maireana species in desert’s rangeland. Atriplex amnicola 949 showed the best performance (table 38) than all comparable Atriplex and Maireana species which showed its vigorous growth habit followed by A. lentiformis, A. cinerea and A. bunburyana species, whereas other A. amnicola 573, 971 gave equal response. The M. pyramidata produced the higher biomass followed by M. polytergiala and M. amoena (table 38).

7d.6.4 Succulence or tissue water contents

Tissue water contents or degree of succulence is an effective mechanism against salt and water stresses. The Maireana species in respect of maintenance of internal tissue water balance showed contrasting behaviour than other growth factors when compared with Atriplex. In general the Maireana species accumulated larger amount of water as compared to Atriplex. All of the Atriplex retained almost a uniform level of internal water contents (table 38).
7d.7 Discussion

The high degree of adaptation exhibited by various Atriplex and Maireana species to a variety of desert environ stresses might be related to a number of adaptation mechanisms to salinity and aridity present in the species. The dominant and effective adaptation is mainly concerned with increased resistance against water loss from the foliage. A better control of internal water balance by Atriplex and Maireana species is given in table 38. Maximum tissue water contents were observed in case of all Maireana species as in other similar desert species like Salicornia herbacea, Haloxylon recurvum and H. salicornicum (Abdullah et. al., 1988; Warren, 1993).

Usually both salinity and aridity have common, sometimes identical and interrelated consequences upon plant growth. Reduction of leaf surface area by possessing very small and fewer green leaves reduced the transpiration loss of water as in many xeromorphic plants, the Atriplex bunburyana species have maintained their internal water balance through reduced and narrow leaves (Waisel, 1972).

Like other halophytes, water stress or haloxeric conditions could not be a limiting factor for the growth of Atriplex (Abdullah et. al., 1990). In Atriplex nummularia (halophytes), the relative water contents increased when grown in saline conditions (Gate, 1972). Thus, in the absence of any visible toxicity symptoms developed by the species under arid and saline environment, it is concluded that differences in the growth and adaptations are related to differences in their compatibility with the maintenance of internal tissue water balance.
7d.8 Conclusion

*Atriplex* have more adaptation potential than *Maireana* species under Cholistan desert conditions. The *A. lentiformis, A. halimus* and *A. amnicola* could be cultivated in the deserts of Pakistan by using saline water resources. These species are quite tolerant to low temperature, cease growth during high temperature and flourish well in the cool season. Thus, growing salt and blue bushes will not only provide the much needed palatable forages for the livestock but also improve the soil physical properties and stabilize the sandy soils against wind erosion. The arrangements relating to control termites, rodents and shifting sands must be made prior to transplant the *Atriplex* and *Maireana* species in the field.
CONCLUSION AND SUGGESTIONS

Pakistan is a country full of geographic variations, endowed with an enormous variety of biophysical, ecological, socioeconomic, and cultural characteristics. A host of different factors are implicated as causes of natural resource degradation. Being a signatory and ratifier of UN Convention to Combat Desertification, Government of Pakistan has also taken up the situation on war footing. In this context, the draft National Action Plan to Combat Desertification (1996) identifies six broad ecological zones of Pakistan, and emphasizes the uniqueness of social relations of resource management in each area. In planning and implementation of anti-desertification actions, careful attention should be paid to the specific characteristics of each area. Lessons learned and proposed remediation in one area, however suggestive for other areas, must not serve as templates for broad application.

Pakistan’s rangelands are degraded. They produce just one third of their potential. Increasing population and livestock pressure, if maintained at the current level, will inevitably lead to desertification and may disrupt the nomadic way of life. The potential for increase in productivity justifies substantial efforts in better range management.

Desertification occurs largely by human action. It follows that it can only be arrested by human action. The emerging solution to the problem recognizes the pivotal role to be played by community based management system, as collectively agreed practices to ensure sustainable grazing.

Community based management system, which is an essential pre-condition to effective range management could be blended with traditional tribal structures so that there is a consensus of the community, or the clan, that they will collectively
support certain actions, such as refrain or delay in moving stock on to certain pastures, until some agreed time. This approach will need the advice, but not the direction, of range management experts and market specialists.

The basic technical solution is improved forms of system, an end to overgrazing, sand dune fixation, the erection of windbreaks, shelterbelts, and improved soil and water conservation.

The first precondition for success in field projects to check desertification is community participation. Projects in which the people themselves plan and run their own self-help schemes, on a small scale, have a much greater chance of success than large projects directed by distant bureaucrats.

Pastoral nomadism is not only an environmentally sustainable way of managing the Cholistan drylands, but it could extend support to national dairy and meat consumption requirements. The likelihood of an increase in the number of livestock, by making feed supplement more accessible and affordable in the dry seasons, could be reduced by increasing offtake through marketing of animals for urban consumption. Support for the livestock sector will automatically increase herders’ income and increased offtake through marketing, reduces the likelihood of overgrazing.

Although the ground water is saline but it can be used for saline agriculture to grow salt tolerant fodder grasses. It is judicious to utilize the land by using ground saline and surface rainwater resources for growing palatable grasses. Biological approach for economic utilization of salt-affected soil is feasible and is the only viable method when the soil is sodic and sweet water is not available for irrigation.
Land system 1 has the best potential for irrigation. Biomass production varies between 300 to 500 Kg/ha and is not particularly well suited for livestock intensification (figure 29).

Land system 2, 3, 4, and 8 are all suited for rangeland enhancement and livestock intensification.

Land system 5, 6, and 7 are not suited for livestock production. Total biomass production being from 120 to 350 Kg/ha. These areas could be usable for wildlife conservation if well equipped with windmills and drinking troughs.

The current situation suggests the following institutional requirements to promote prosperity of the rangelands and its pastoralists.

- Development of a social organization by the traditional pastoralists which will implement and manage rangelands interventions;
- Government agencies should work with, not for pastoralists. Closer contact and consultation will be of benefit to both parties;
- Consolidation of Government policy into the hands of a single authority for coordination of policy, planning, research, extension development (especially of water) and training. Execution of work by individual departments would continue;
- The need for graziers association, their participation should result in improved rangelands and animal production;
- Provision of an independent sociological organization or persons, co-opted to work with the Development Authority and the pastoralists organizations to facilitate the movement of ideas and ensure equity of treatment between competing groups.

Establishment of the above organizations is a pre-requisite to the conduction of the following technical and training exercises.

- Definite policy and unified regulation of all water development including tobas, bearing in mind the needs for sustainable yields of both groundwater and pastures in the long-term.
Pastures evaluation research could be consolidated as a joint effort between the Pakistan Council of Research in Water Resources (PCRWR), Forestry Department and Cholistan Institute of Desert Studies, Islamia University Bahawalpur. The pooled resources should carry research into the next stage of evaluation of plant performance under grazing conditions. The results would finally be used in the development of grazing management systems compatible with the traditional system and sensitive to the implications of innovation to the pastoralists;

Research to be conducted on the efforts, present and potential of the *Calligonum* caterpillar on pasture production and, if need be, on methods for its control;

Continuation of the grass reseeding and pastures protection programme, but in a new form and in agreement with the pastoralists organization;

Restoration of tree density at appropriate sites where protection is offered by pastoralists;

Continue with attempts to develop the *khar* (soda ash) industry and examination of the *Atriplex* potential;

Determination of grazing times most suitable for promotion of grass recovery and vigour;

Social services by way of health, sanitation, drinking water, education and cottage industry training;

Livestock industry promotion including marketing, milk collecting centers, feedlots, poultry and vaccination.

Education for pastoralists can be most effectively organized through an institution that directly involves them in educational programmes, which emphasis on the management of their resources. Such a centre should be situated at Derawer Fort or any other location, which can serve large grazing areas. The centre may be created by the Cholistan Development Authority (CDA) and should have all the necessary facilities to achieve the following objectives:

- Organize short seminars on resource management;
- Coordinate the roles of Development Agencies and extension workers;
- Prepare, evaluate and produce educational materials in the form of films, slides, Radio, TV programmes, posters and charts for the extension programmes;
- Prepare training courses for extension workers in leather cutting, handicrafts, water harvesting techniques, soil and vegetation rehabilitation and training for veterinary personnel, first-aid and trade etc.

Direct participation of Cholistanis in education and development programmes in grazing scheme should be seen as absolutely vital. Local leaders should be nominated by the pastoralists to form a Range Development Committee. The committee should be entrusted with supervising the implementation programmes and grazing movements and achieve the following objectives:

- To assist in implementation of development programmes;
- To educate pastoralists on resource management and range use;
- To assist extension workers in their field operations;
- To supervise development and assist in security programmes.

In order to be effective in management roles the Range Development Committee members should be given short but frequent seminars and courses at the training centre. Seminars organized by the Range Development Committee members and other pastoralists should aim at:

- Acquainting groups with management programmes;
- Demonstration some of the recommendations made;
- Providing basic scientific information on factors causing land degradation;
- Stressing the need to increase public education.
Similarly courses to be offered at the training centre should include:

- General environmental degradation;
- Soil degradation and rehabilitation;
- Range management and grazing regulations;
- Destruction impacts on vegetation by man and his livestock;
- Water management, development of wells and watering points;
- Livestock marketing;
- Veterinary input and livestock disease education;
- Home economics.

The use of radio and TV as a medium of communication with Cholistan pastoralists should be exploited. Radio and TV programmes should be broadcast in the local language. These programmes should provide an opportunity for further learning regarding climate and the pastoral life, vegetation and land use, destructive effects of over-grazing on vegetation and land resources, livestock marketing, livestock diseases and veterinary inputs.

Since adult illiteracy is very high in Cholistan, it is recommended that each village should be provided with an adult-literacy teacher. Such teachers need not have a very high level of education. Individuals who have completed intermediate level education would be adequate to teach people how to read and write.

Cholistan is one of the most under-developed and backward regions of the country. The people lack even the basic amenities of life. Their socio-economic profile is nomadic pastoral and livestock production is the major economic activity. Scarcity of water and lack of adequate infrastructure are among the major constraints for the development of this arid tract. Lack of roads and communication has hampered the development of this area by making its accessibility very difficult for the Government officials, traders, visitors, police, and security. It is suggested that to
utilize the grazing resources in the area fully, to facilitate the development of an efficient infrastructure and respond quickly to any needs of the people, a good network of roads is essential.

Tourism is also a means of exploitation and developing this arid region needs careful consideration. Characteristics desert fauna and flora of Cholistan, its cultural heritage, historic monuments, ruins of old forts, remnants of the ancient "Hakra Civilization", dried Hakra River bed, its primitive crafts and life style may attract desert lovers and those interested in studying its arid ecosystem. With the development of tourism, it is expected that local arts and crafts will find avenues for fuller expression. Before embarking on this programme, it is essential to make a careful evaluation of its impact and benefits to the local people. Beside, tourism development will require a good infrastructure including a network of roads, transport, food services, health services, water supply and camping facilities.

Since the government has been lax or ineffective so far, the role of a support or umbrella NGO could be very effective in Cholistan in providing social service to the people. These groups have been most successful where they focus on multipurpose community social organizations. NGOs have the greatest potential for success in the battle against desertification and for better range management. They owe this potential to the small and local scale of their operations, their flexibility, and their requirement for local participation.

Herding communities of Cholistan recognize the value of education for their children as an entry to new employment opportunities. Because schools are inaccessible and government is not likely to provide mobile schools with curricula appropriate for herding communities, this is a clear opportunity for NGO action. Especially lacking are educational opportunities for girls.
The condition of health and sanitation among Cholistan herding communities are poor. Disease, exacerbated by periodic undernutrition, is rampant, and herders expend considerable sum on often-dubious medical procedures and drugs. Health is another arena for donor and NGO action in the region. Special attention should be given to women’s health issues, since women suffer rates of morbidity but are culturally discouraged from discussing female-specific health problems. Conditions of health and sanitation are further exacerbated by periodic shortages of safe, reliable drinking water.

Desertification is one of the most serious environmental and socioeconomic problems threatening the humankind on the eve of new age and millennium. I am confident that my recommendations will give a priori model for the planners of Pakistan to overcome this menace.

In the light of above suggestions I would like to suggest that for the successful implementation of CCD (1994) in Pakistan a very strong local involvement is needed to achieve the expected results. Therefore, it is recommended that Government of Pakistan must create a policy for participatory development based on local materials and techniques within the framework of existing indigenous and public property institutions.
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APPENDIX - I

PERSONNEL INFORMATION:

1) Description about the area:
   a) District: i) Bahawal Pur ii) Bahawal Nagar iii) Rahim Yar Khan
   b) Tehsil:
   c) Union Council:
   d) Post Office:
   e) Chak No.

2) Mother language:
   a) Urdu,
   b) Punjabi,
   c) Seraiki,
   d) Other

3) Religion:
   a) Muslim,
   b) Hinduism,
   c) Christianity,
   d) Other

4) Information about the settlement:
   a) Whether you are local inhabitants or,
   b) Immigrants

5) Size of the family:
   a) 1-3 persons
   b) 4-6 persons
   c) 7-9 persons
   d) Above 10 persons

EDUCATIONAL FACILITIES:

6) Number of school going kids:
   a) Male: ________
   b) Female: ________

7) Level of education:
   a) Below primary:
   b) Primary:
   c) Middle:
   d) Matriculation:
   e) Intermediate or above:

8) Distance of school from your village or chak:
   a) 1-3 Km
   b) 3-6 Km
   c) 6-9 Km
   d) Above 9 Km

9) What is the general age at which you get your child admitted in a school?
   a) 4-6 Years
   b) 6-8 Years
   c) 8-10 Years
   d) 10-12 Years
MEDICAL FACILITIES:

10) What type of medical facilities is available in your village or chak?
   a) Doctor (MBBS)
   b) Hakim
   c) Dispenser
   d) Homeopath
   e) Other

11) Give the conditions of existing female health facilities in your village or chak.

12) Please let us know about any government or charity clinic in your village or chak?
   a) Yes
   b) No

13) Have the children in your village or chak been vaccinated according to child immunization programme?
   a) Yes
   b) No

SOCIAL AND FAMILY MATTERS:

14) What is the marriage system adopted in your family?
   a) Love marriage
   b) Arrange marriage
   c) Court marriage
   d) *Watta Satta* (exchange a bride for a bride)

15) Do females have the right to consent or disapprove to a family arrange marriage?
   a) Yes
   b) No

16) Does head of the family consent family matters for making a decision?
   a) Yes
   b) No

17) Are daughters married for waging of debts still in practice in your family?
   a) Yes
   b) No

18) Is dowry compulsory for the marriage?
   a) Yes
   b) No

19) Is childhood marriage is still in practice in your family?
   a) Yes
   b) No

20) Is *qum* practice in your family or clan?
   a) Yes
   b) No

21) Do parents threat their daughter in marriage for animals?
   a) Yes
   b) No
22) Are women given the rights of inheritant in father’s or husband’s property?
   a) Yes
   b) No

23) What is the normal routine of women’s time to work (in hours)?
   a) Domestic Work:
      i) Food cooking.
      ii) Household chores.
      iii) Water carrying.
      iv) Firewood gathering.
   b) Seasonal Farming Activities:
      i) Planting.
      ii) Weeding.
      iii) Harvesting.
   c) Livestock Management:
      i) Feeding.
      ii) Milking.

24) What is the herd size of your family or clan?
   a) Sheep:
   b) Goats:
   c) Buffalo:
   d) Cows:
   e) Camels:

25) Do you use meat in your diet:
   a) Daily
   b) Weekly
   c) Monthly

26) What is the major source of water supply in your village or chak?
   a) Pond
   b) Well
   c) Toha
   d) Kundi
   e) Tube well

27) Are you satisfied with the activities of Cholistan Development Authority (CDA)?
   a) Yes
   b) No

28) Any other useful information or suggestion.

Thanks for your cooperation
Farooq Ahmad
Department of Geography
University of Karachi.