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Natural Resource Conservation, Poverty Alleviation, and Farmer Partnership

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1. INTRODUCTION

Agriculture has now been seen in its multiple roles like contributing to development as an economic activity, source of livelihood, provider of environmental services and a unique instrument to overall development. As an economic activity, it is a source of growth for national economy, food security, foreign exchange as well as provider of investment opportunities for agro-based industries and rural non-farm economy. As source of livelihood, it provides jobs to majority of the people, especially the small holders, landless and the poor. In terms of environmental services, being the major player in underground water depletion, agrochemical pollution, soil exhaustion and global climate change due to greenhouse gas emissions, agriculture can create good and bad environmental outcomes. Its environmental contributions in managing watersheds and preserving biodiversity are generally unrecognised and unremunerated. Agriculture has well established record as an instrument for poverty reduction[1] as well as a leading sector for overall growth in the agriculture-based countries of the world [World Bank (2007)]. In future, agriculture has to commit more promises (e.g. bio-fuel) to the nation without compromising over primary responsibility of food security along with poverty alleviation, conservation of natural resource base, environment protection etc. Unfortunately, the agriculture has been vastly underused for development.

In the world, new approaches for reducing poverty among farming communities are also under investigation among development circles of the world. These approaches are mainly aimed at improving rural livelihoods through introduction of new technologies, community organisation, awareness creation, capacity building and human resource development, and accumulation of physical and natural capital. Agriculture is the only sector which is heavily dependent on the quality and utilising patterns of natural resources for higher productivity. Optimum utilisation of the scarce natural resources for more productive purposes is imperative for many reasons like very high stake for rural livelihood, health and productivity consequences of uncontrolled utilisation and high

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[1]Ahluwalia (1978); Timmer (1995); Gallup, *et al*. (1997); Fan and Rao (2007); Hanmer and Nashchold (2000).

costs of migration to urban areas etc. Unfortunately, these natural resources (land, water, forests, rangelands and fisheries) were exploited for high growth targets without giving any due consideration about their regeneration, conservation and rehabilitation. The height of the issue is that those who exploited these resources for the development of the nation, they themselves are now more suffering from vagaries of the nature like droughts, disease epidemics, low agricultural productivity and poor standard of living, all indications of poverty. Another more serious dimension of the issue is that the farming community is not realising the severity of the issue in its true spirit, while the public, private and NGOs working for the rehabilitation, regeneration, protection and conservation in their own pre-designed domains at least/without any institutional coordination and the volume is also meagre in amount. It is necessary that the farmers who are real custodians of these natural resources should get empowered because they are real affectee of the consequences. They can better realise the intensity of the problem, the kind and appropriate institutional support needed for reversing the natural resources quality deterioration process, rather than the institution implementing their own means and methods. The primary objective of this paper is to sensitise the policy makers and development planners to create and practice empowerment among farming communities for healthy maintenance of the natural resources they possess for future sustainable use to keep them away from poverty trap. The present paper looks into the justifications for empowering and means of empowering the custodians of natural resources on which agriculture sector is entirely based for the noble cause of poverty alleviation.

This paper is organised into seven sections. Section 2 discusses the status of agro-natural resources and their utilisation trends in the past. The agro-natural resources considered in this section are land, water, rangeland vegetation and its biodiversity. Section 3 informs about the support of research and development institutions available at local, provincial and federal levels. Section 4 attempts to establish a poverty-natural resource degradation link. Section 5 provides justifications about why empowerment is needed for the cause of poverty alleviation and explains the mechanism by which empowerment may leads to poverty alleviation. Section-6 highlights the implementation problems of the empowerment process along with the possible solutions. Section 7 finalises the paper after summarising the salient points and suggesting recommendations.

2. PAKISTAN'S AGRO-NATURAL RESOURCES AND THEIR UTILISATION TRENDS

Pakistan possesses a great variety of natural resource base ranging from majestic high mountains of Himalayas, Karakorams and Hindu Kush snow covered peaks as a source of water for irrigation and electricity generation, down the inter-mountain valleys in the north for producing fruits, vegetables and other high value crops, further down the vast rich irrigated plains in the Indus basin producing major and minor food and cash crops as well as a major contributor in agricultural GDP, stark deserts and impressively rugged rocky expanse of plateaus in Balochistan providing rangelands and custodian of a significant proportion of livestock population of the country. The prime objective of this section is to address the importance of natural resource base for supporting the crop and livestock sub-sectors in terms of its nature, magnitude and consequences of their uncontrolled utilisation.

2.1. Land and Soil Resources[2]

Land is the most fundamental among natural resources on which human existence and prosperity depends. Its particular use and management affects: (a) the quantity and quality of the production and on-farm employment; (b) the degree of pollution / degradation of not only land but also water and air; and (c) integrity of the biological systems upon which human life depends [Siddiqui (1997)]. Optimum use of this resource not only ensures continued availability of the basic human needs for food, fiber and shelter, but also improves the overall environment. A large variety of soils are found in Pakistan, which vary significantly in kind and distribution. Although the country's soil resources are also vast, but good quality soils that form prime agricultural land are limited. Pakistan also cannot ignore the options for better utilisation use of poor quality soils [Mian and Mirza (1993)]. Various types of surveys conducted by Soil Survey of Pakistan during 1980s shows that about 750 different types of soils are found in Pakistan, which vary in kind, and distribution. These are grouped into eight land capability classes according to their agricultural potential or relative suitability for sustained agricultural use. Of these first four are meant for arable use and other four are for non-arable uses like forestry and ranges (Annexure 1). These entail adopting different approaches to optimal and sustainable use of this resource. In other words, the need of the day is to protect the prime agricultural lands from misuse and recover the degraded soils.

The total area of Pakistan is 79.6 million hectares, of which 70 percent is arid to semi-arid. About 50.88 million ha (or 63.9 percent) are rangelands[3] and only 22 million ha (or 27.6 percent) are cultivated lands. The ecologies of NWFP and Northern Areas range from semi-arid to humid. The Sindh province is primarily arid while Punjab and Balochistan have arid-semiarid ratios as 58:29 and 43:57, respectively. By ecologies, 51.5 percent of total area is arid, 36.9 percent is semi-arid, 5.4 percent is sub-humid and 6.2 percent is mixed. About 41 million hectares is solely arid including about 11 million hectares comprises deserts where mostly the climate is hyper-arid [PCRWR (1999); Iqbal, *et al.* (2000)].

The present use of land is not in accordance with its potential. Rather it is based on opportunity, economic status and the socioeconomic needs of the user. While much of the land on steep mountainous slopes suitable for forestry and rangelands are now used for food crops. A significant proportion of good to very good lands in Indus plains are under irrigated forests or are used for non-irrigated purposes. Extensive areas in Thal, Tharparkar and Cholistan have been over utilised for grazing and now seriously threatened by desertification. Large tracts are available in Indus basin are under utilised due to water and economic constraints created by diverting resources to relatively unimportant lands. Similarly, one can easily find general cultivation of basmati rice on well-drained loamy soils in northern Punjab, while these soils are ideal for cultivating crops like maize, potatoes, sunflower and pulses. Sometimes infrastructure and policy mistakes are also responsible for creating adverse impacts on cropping patterns. For

[2]This section is mainly drawn from Mian and Mirza (1993).

[3]The rangelands of Pakistan are consisted of Western Balochistan ranges (18.50 million ha), Central Balochistan ranges (8.00 million ha), Desert rangelands (7.97 million ha), Eastern Balochistan ranges (5.00 million ha), trans-Himalyan grazing lands (3.50 million ha), Kohistan ranges (2.38 million ha), Alpine pastures (1.68 million ha), Pothwar scrub ranges (1.68 million ha), Suleiman mountain ranges (1.50 million ha) and Himalayan forest grazing lands (0.67 million ha).

instance, setting up of sugar mill in Thal led to extensive sugarcane cultivation aggravated waterlogging problems in the area.

Soil erosion by water is one of the severe problems of Pakistan. It is more noticeable in Pothwar plateau in the form of sheet, rill and gully erosions. Other forms of erosion like pinnacle erosion, piping and slumping are also common here. Its major causes are destruction of natural vegetation cover by uprooting and cutting plants for cultivation, fuel, timber and forage needs; use of bulldozer land leveling to bring the land under plow; arable farming on shallow lands in steep areas; inadequate or ineffective terracing, low and weak embankments and poor water control; and rapid decline in the organic contents in cultivated soils due to continuous cropping without fertiliser or organic matter recycling. Its consequences can be revealed in the form of decline in agricultural productivity and increased dependence of agricultural imports, continued deterioration of rangelands and forest reserves and their productivity for livestock farming, fuel wood and timber production, increased sedimentations in water reservoirs and channels reducing their productive life [Mian and Mirza (1993)].

In Pakistan, the soils affected by various types of salinity and sodicity constitute 5.328 million hectares, half of it in Punjab and 40 percent in Sindh and 9 percent in Balochistan province [Mian and Mirza (1993)]. The problem of water logging in Pakistan is differently reported by different agencies. Water logged areas represent 5-10 percent of total landscape of the country. The problem is not as grave as it has been generally reported. Water logging is limited to few specific areas because of their inherent hydrological characteristics. The concept of water logging is not well understood. Many people regard land as waterlogged if the water table occurs within 3 meters (or 10 feet) depth of the surface. Soil surveys found that almost no crop suffers from excessive moisture as long as the water saturation zone remains below 1.5 meters depth in all, except sandy types of soils. In sandy soils, rather than suffering, the crop benefit from a rise in the water table to within 1 meter of the surface. In Pakistan, the area having water table within 1.5 meters depth constitute 1.554 million hectares[4], 45 percent is in Punjab and 40 percent in Sindh, 6 percent in NWFP and 9 percent in Balochistan province. Like salinity and sodicity, water logging is mainly a consequence of old hydrological processes, still operative in much of the area with specific geo-morphological and physiographic characteristics.

2.2. Water Resources

Water has extremely important role in our economy. Pakistan agriculture is also heavily dependent on water availability.[5] About 88 percent of available water is used in agriculture. The per capita availability of surface water is dwindling from 5300 cubic meters in 1951 to 1100 cubic meters in 2006, which is further projected declined to 1000 in years to come. According to one estimate about 29 percent of total area suitable for agriculture can become productive if water is made available for irrigation. In other words, a little less than one-third of agricultural potential of Pakistan remained untapped because of non-development of water resources and its associated infrastructure

[4]About 53 percent of it is below 0.5 meters in depth.

[5]Pakistan relies on irrigation for more than 90 percent of its agricultural production and during the past 35 years it has been fast exploited. Still Pakistan's crop and horticulture sector are mainly concentrated in the areas where either rainfall is relatively high or there is a control over water supply through canal and/or tubewell water.

[PILDAT (2003)]. The water uses in 2003 were estimated at 108 million acre feet and our demand would expand to 147 million acre feet during 2025 [Ministry of Water and Power (2002); Pakistan (2007b)]. The surface water availability is suffering from a number of issues like lack of trust among provinces especially between Punjab and Sindh, differences among provinces about interpretation of Water Apportionment Accord of 1991, Construction of Greater Thal canal in Punjab, Reduction of storage due to silting of existing reservoirs, and wastage of water in the irrigation system [PILDAT (2003)].

At present, Pakistan is one of the world's most arid countries, with an average annual rainfall of below 240 mm. The population and the economy of the country are heavily dependent on annual influx of about 180 billion cubic meters of water into the Indus river system of 5 rivers, mostly derived from snow melt in the Himalayas. In the early 1960s, it was thought that Pakistan is doomed, ironically to a watery and salty grave. Now Pakistan is one of the most water stressed countries of the world in terms of balance between population and available water. There is no additional water to be injected into the system and there is also high risk water environment. There are abundant evidence on extensive degradation of natural resource particularly water on which arable farming is heavily dependent. Ground water is highly over-exploited[6] in many areas, and its quality is deteriorating[7]. Flooding and drainage problems are going to get worse, especially in the lower Indus basin. Pakistan has to invest and invest soon in costly and contentious new large dams. Above all, the water productivity is also low [World Bank (2005)].

The use of ground water in irrigated agriculture of Pakistan has long history. In early days, open wells, Persian wheels, karezes, reciprocating pumps and hand pumps were means of extracting underground water. Large scale pumping of underground water started during 1960s with the launching of SCARPs (Salinity Control and Reclamation Projects) project. Thousands of large-capacity tubewells (0.084 to 0.14 m^3/sec) were installed at very low water table to supplement irrigation supplies. The wild proliferation of private tubewells of around one cusec (0.028 m^3/sec) capacity by the farmers in 1970s and 1980s, subsidised electric supply and introduction of locally manufactured diesel engines provided an impetus for sharp increases in the number of private tubewells started from mid 1980s (Figure-2). It was estimated that about 25 billion rupees are annual spent on private tubewells and the annual benefits harvested in the form of agricultural production worth Rs.150 billion [Shah, *et al.* (2003)]. The estimated number of tubewell water beneficiaries were over 2.5 million farmers, who exploit ground water directly or purchase tubewell water from their co-villagers [Qureshi, *et al.* (2003)].

In 2005-06, there were 957,916 private tubewells in Pakistan, with total ground water extraction as 42.31 million acre feet and the annual growth was estimated at 7.16 percent per annum during 1970-71 to 2005-06. During this period, the public and private tubewell population were respectively increased by –5.65 percent and 10.71 percent while the diesel and electric tubewells were increased by 7.30 percent and 2.96 percent, respectively. The density of tubewells is highest in Punjab province [Pakistan (Various

[6]Over the past 40 years, due to adopting *laissez-faire* approach, the exploitation of groundwater has brought enormous economic and environmental impacts. Groundwater now accounts for almost half of all irrigation requirements. In rainfed areas of Balochistan, farmers are pumping from depths of hundreds of meters and in the sweet water areas of the Indus Basin, depletion is now fact in all canal commands [World Bank (2005)].

[7]There are serious and growing problems with groundwater quality as about 20 million tons of salts accumulating in the system every year.

Issues)]. Pakistan's ground water economy is largely farmer-financed, 77 percent of tubewell owners used their own money to install tubewells and about 10 percent used bank loans while remaining has taken loans in addition to their own money. Farmers' dependence over groundwater is not uniform across the country. It varies according to climatic conditions, cropping patterns and availability of surface water supplies. However, about 60 percent farmers depend upon groundwater to meet their total crop water requirements. Punjab agriculture has become heavily dependent on ground water and its quality also greatly varies from place to place attributable to variation in origin, source of recharge and patterns of groundwater movement in the aquifers [Qureshi, *et al.* (2003)].

2.3. Rangeland Vegetation and Biodiversity

The rangelands[8] economy of Pakistan is extend from alpine pastures in the northern mountains to temperate and Mediterranean ranges in the western mountains and arid/semi-arid deserts of the Indus Plain. The rangelands are available from just sea level in the south to over 8800 meters elevation in the northern mountainous regions of Himalayas. Extreme climatic variations in temperature and rainfalls patterns are also present in these ranges. Due to bio-climatic variations, the range vegetation varies from one area to the other. About 60 percent of the total area of the country is rangelands. This area supports a notable proportion of total livestock population of Pakistan. Estimated forage production and improvement potential in main grazing areas of the country is given in Table 1. The information on vegetation types present in these rangelands is given in Annexure 2. It clearly shows the extent of biodiversity present in the rangelands of Pakistan. The economic importance of some commonly available vegetation in rangelands is given in Annexure 3.

The livestock farming is an important source of livelihood for the farmers in the rangelands, deserts and marginal lands who are also suffering from poverty. In these areas, the crop cultivation prospects are relatively low. Due to over increasing human and livestock population, there is enormous pressure on natural vegetation in almost every agro-ecological region of the country. For instance, in Balochistan, livestock production primarily depends upon rangelands. Sheep and goats obtain about 60 percent of their feed from rangelands [Zaffaruddin (1977)] while in Balochistan, 90 percent of the required livestock feed is provided by rangelands [FAO (1983)]. Therefore, most rangelands in Pakistan are overused due to certain practices, customs and problems. The rangelands in common tribal or village property areas are not conducive to the regulation of proper grazing. The nomadic grazing also lead to over exploitation of natural vegetation with little rehabilitation/regeneration efforts. Both lead to extensive erosion of carrying capacity[9] of these rangelands. The rapidly increasing demands for livestock products[10] could cause further enormous pressure on these rangelands, which may result more environmental degradation in the country, if science-based regeneration and rehabilitation measures are not adopted [Pakistan (2007b)].

[8]In Pakistan, the term rangeland is locally called as "*Chiragah*", which is erroneously considered as wasteland and synonymous with desert or arid land. In 1973, the National Commission on Range Management defined rangelands as "Uncultivated areas (although sometimes disturbed by un-thoughtful cultivation) that support natural or seeded herbaceous or shrubby vegetation with or without trees" [Mohammad (1989)].

[9]Carrying capacity means the natural capacity of land and/or rangeland to feed human and/or animal population at given technological level [Tiffen and Mortimore (2002)].

[10]In Medium Term Development Framework (2005-2010), the livestock sector is desired to grow at 5 percent per annum [Pakistan (2005)].

Table 1

Estimated Annual Forage Production from Rangelands of Pakistan

Rangeland Type	Distribution	Area (Million ha)	Current Production		Improvement Potential	
			Dry Matter (t/ha)	Total Dry Matter (Million t)	Dry Matter (t/ha)	Total Dry Matter (Million t)
Alpine pasteurs	Northern mountains, altitude above 3500 meters	1.68	1.50	2.52	2.50	4.20
Trans Himalyan Grazing Lands	Hindu Kush region (Dir, Chitral, Swat, Gilgit, Chilas, Skardu districts)	3.50	0.60	2.10	2.00	7.00
Himalayan Forest Grazing Lands	Western Himalayas (Siran, Kaghan, Neelam and Jhelum valleys)	0.67	0.60	0.40	3.00	2.01
Pothwar Scrub Ranges	Pothwar Plateau and Salt Range (Attock, Islamabad, Rawalpindi, Chakwal and Jhelum districts)	1.68	1.50	2.52	4.00	6.72
Desert Rangelands	Thal, Cholistan, D.G. Khan and Tharparkar Deserts	7.97	0.50	3.98	2.00	15.94
Kohistan Rangs	Kithar range of Sindh and Balauchistan (Karachi, Thatta, Dadu and parts of Lasbella district)	2.38	0.40	0.95	2.00	4.76
Central Balochistan Ranges	Quetta and Kallat Division	8.00	0.50	4.00	1.00	8.00
Eastern Balochistan Ranges	Loralai, Zhob and Sibbi districts	5.00	0.40	2.00	1.00	7.50
Western Balochistan Ranges	Desert areas of Chagai, Kharan, Punjgur, Makran, Turbat, Gawadar and Lasbella districts	18.50	0.30	5.55	0.80	14.80
Sulaiman Mountain Ranges	Western mountains along Afghanistan border	1.50	0.30	0.45	2.00	3.00
Total		50.88	0.66	24.47	20.80	73.93

Source: Mohammad (1987, 1989).

Forests[11] occur at 5 percent of the total land area of the country. Of this total forest area, communal forests are just one-third (32.8 percent) and remaining (state owned and privately owned forests) is under protected forests, performing the soil conservation, watershed protection and climatic functions. Pakistan is one of the lowest forests covering country in the world [Pakistan (2007a)]. Forestry is the major land use in northern Pakistan by crop cultivation and livestock grazing is prevalent in the forest areas. The natural flora in some areas is also seriously affected by water logging and salinity. Aridity and prolonged droughts in arid lands have also affected the vegetation cover in these areas. The total national demand for different types of woods was 36972 thousand cubic meters in 2003 which will increase to 52619 thousand cubic meters during 2018. The demand of industrial wood based products was 5255 thousand cubic meters in 2003 which would increase to 9943 thousand cubic meters during 2018. The demand of fuel wood in 2003 were estimated as 24358 thousand cubic meters per annum [PARC-MELGRD-UNEP-ESCAP (2002)].

[11]Under Millennium Development Goals of Forestry sector, Pakistan is committed to increase its forest cover from existing 5 percent to 7 percent by 2011 and to 8 percent by 2015 [Pakistan (2007)].

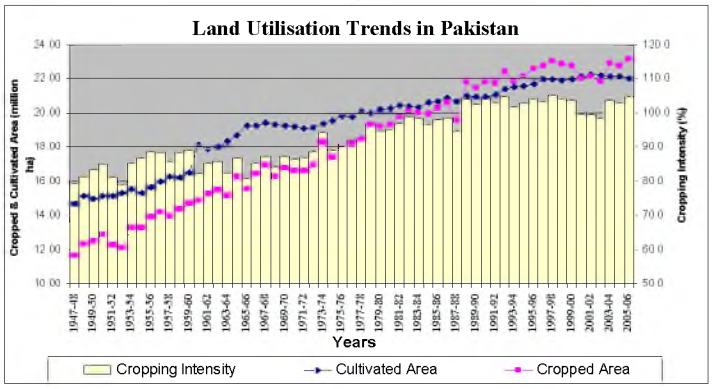
Khalil (1960) and Said (1961) studied the constraints of range and forestlands, and identified the following biophysical factors causing their deterioration in Pakistan. Some of the major constraints identified by Sub-committee on Range Management are listed below [Pakistan (1983)]:

- Absence of any independent range management agency vested with authority, responsibility and accountability to undertake a range management program.
- Lack of awareness, appreciation and encouragement on the part of senior administration and discouraging those having post-graduate degree in range management from advanced countries.
- In any range management/development program, effective cooperation and participation of people is essential. Such participation by stockmen has been almost completely absent in all range management programs implemented so far.
- The funds available for range management/improvement are generally very meagre and spreading them over large areas minimises their impact.
- Range management research or development programs launched and executed so far lacked necessary support, such as adequate resource analysis and surveys.
- Since range management activities are carried out by the Forest Department, it continued to be the secondary importance in the forest development activities.
- Exceptionally difficult and unfavourable working conditions and the absence of suitable incentives have dissuaded members of the Forest Service from accepting range management jobs in the Forest Department.
- Therefore, the funds available for such projects are very meagre. Moreover, the scientists and development practitioners working for agricultural resource conservation and rehabilitation generally receive low regards in terms of allowances and promotions.
- Planning and development authorities generally put low priority to range development projects, as these do not measure up to criteria involving direct economic returns.

2.4. Natural Resource Utilisation and Availability Trends

Regarding land utilisation trends in Pakistan, there has been almost regular improvement in the cropping intensity since inception, however, it was relatively more pronounced after the advent of Green Revolution. The total cropped area was first time surpassed the total cultivated area in 1988-89 and maintained this status till today. This indicates that the average cropping intensity is now slightly higher than 100 percent. From 1947-48 to 2005-06, the average annual growth in cultivated area, cropped and cropping intensity were estimated as 0.70 percent, 1.18 percent and 0.48 percent, respectively (Figure 1).

Fig. 1.

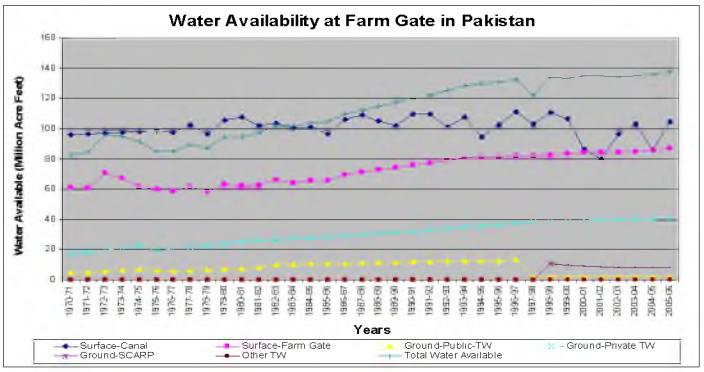


Annual Growth Rate of Land Use Patterns from 1947-48 to 2005-06

	Cultivated Area	Cropped Area	Cropping Intensity
Annual Growth Rate (%)	0.70	1.18	0.48

On the other hand, a regular increase in total water availability is observed from 1983-84, attributed to improvements in canal water availability at farm gate despite the discharge at canal heads has declined overtime and simultaneous regular increase in pumping of ground water by private tubewells. From 1970-71 to 2005-06, the average annual growth in total water availability at farm gate was 1.57 percent. In this period, the water availability at canal head had declined at 0.03 percent per annum while canal water at farm gate was increased at 1.18 percent per annum, attributed to development programs. During the same period, the ground water availability from public tubewells was declined at 3.08 percent per annum while ground water availability by pumping from private tubewells was increased at 2.46 percent per annum (Figure 2).

Fig. 2.



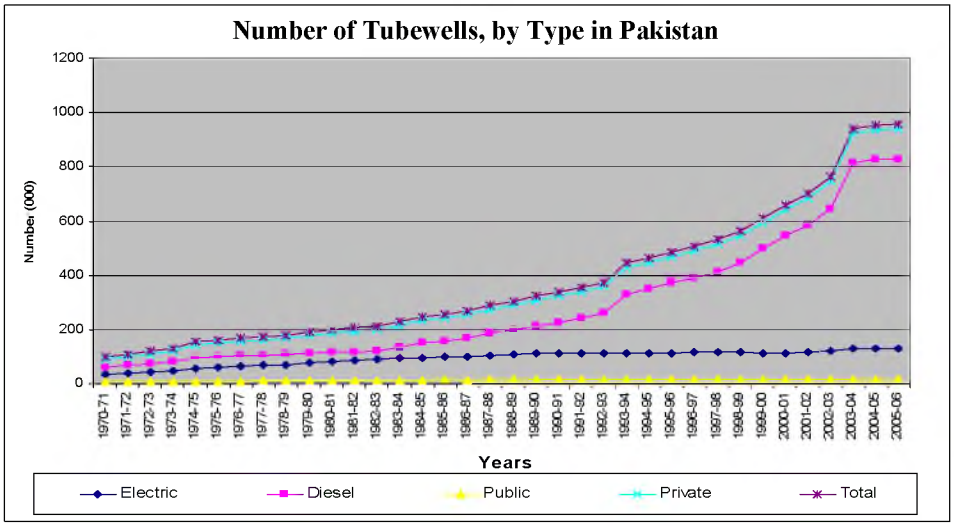
Annual Growth Rates of Water Availability from 1970-71 to 2005-06

	Surface Water		Ground Water		
	Canal Head	Farm Gate	Public Tubewell	Private Tubewell	Total
Annual Growth (%)	–0.03	1.18	–3.08	2.46	1.57

It was estimated that total tubewell population was grown at 6.12 percent per annum. A significant increase in the electric motor and diesel engine driven tubewells has taken place during 1970-71 to 2005-06 with average annual growth recorded as 2.96 percent and 7.30 percent, respectively. The public and private tubwells were grown as 2.17 percent and 6.31 percent per annum, respectively (Figure 3). This has led to over pumping of ground water creating problems of various natures.

Fodder is a limiting factor in livestock production in the rangelands and desert ecologies. On of the major reason for the low productivity of livestock is deteriorating resources of livestock feed. Trees and shrubs can provide nutritious supplemental feed to livestock during lean period because they are perennial and have dept root system, hence, can tolerate drought. On the other hand, in Pakistan, the green fodder produced can hardly meet 51 percent of the feed requirements of dry matter [Haqqanni, *et al*. (2003)] and the remaining demand is met from forages, grazing, cereal grains and their by-products, post harvest grazing and oilseed cakes. There are still shortages of 26 million tons of total digestible nutrients and in terms of total digestible protein, the deficiency amounts 1.58 million tons. Therefore, the livestock milk productivity is much below the potential and vulnerable to diseases and low life expectancy [Ali, *et al*. (2005)].

Fig. 3.



Annual Growth Rate of Tubewells Population by Type from 1970-71 to 2005-06

	Electric	Diesel	Public	Private	Total
Annual Growth (%)	2.96	7.30	2.17	6.31	6.12

It can be concluded that in the past the natural resources have been both extensively and intensively utilised to generate the respectable growth in the agriculture sector. These resources are primarily used for the cultivation of major crops. The vegetative resources are also intensively utilised by livestock sub-sector of the agriculture.

3. INSTITUTIONAL SUPPORT

A large number of institutions at federal, provincial and local levels are involved in carrying out research and development activities for the controlling desertification and conservation of natural resources. At federal level, the institutions involved in natural resource conservation research and development are: (i) Pakistan Agricultural Research Council; (ii) Pakistan Council for Research in water Resources; (iii) Water and Power Development Authority (WAPDA) and its institute for Water logging and Salinity; (iv) Arid Zone Research Center at Quetta and its allied institutes; (v) Space and Upper Atmosphere Research Commission (SUPARCO), Islamabad; (vi) Soil Survey of Pakistan; (vii) Pakistan Forest Institute, Peshawar; and (viii) Meteorological Department. The provincial and local institutions include Agricultural Universities including the University of Arid Agriculture, Agricultural Research Institutes/Stations in Arid and Semi Arid areas, Agency for Barani Area Development Punjab, Forestry Research Institutes/Stations/Divisions, Sindh Arid Zone Development Authority at Karachi, Cholistan Institute of Desert Studies and Cholistan Development Authority at Bahawalpur, Punjab Wild Life Department. The NGOs and CBOs involved in the business are: International Union for Conservation of Natural Resources (IUCN), Sustainable Development Policy Institute (SDPI), Society for Conservation and Protection of Environment (SCOPE), Agha Khan Rural Support Programme (AKRSP), Gulf Rulers, Pakistan Institute for Environment and Development Action Research (PEIDAR) and Rural Development Foundation [PARC-MELGRD-UNEP-ESCAP (2002)], Tharparkar Rural Development Program (TRDP), Baanh Beli in Tharparker, etc.

All these institutions are working primarily for the betterment of their respective geographical areas and welfare of the farmers. No doubt, the objectives/functions of these agencies are laudable in their own place, but a replication of their efforts can be easily observed, which signifies the lack of co-ordination among the development vis-à-vis research institutions. On the other hand, local population is hardly aware of their activities it is evident from the negligible adoption of most of the technological developments made so far. This has been observed in Cholistan [Iqbal, *et al.* (2000)], Thal and Tharparkar [Farooq, *et al.* (2007)]. Many such examples may be available for other agriculturally less developed areas also. This is also because most of the technologies generated so far are still in the experimental tests and are not extensively demonstrated. It is suggested that there should be some co-ordinating department at province level made responsible for careful scrutiny of the research, extension and development plans as well as maintains their mutual co-ordination. This department should also investigate into the methods of creating awareness along with promoting local involvement in testing and the adoption of latest technological developments in crop and livestock. The local development authorities, if present, may also take such responsibilities.

4. POVERTY-NATURAL RESOURCE DEGRADATION LINK (PNRD-L)

The natural resource building has crucial role in reducing poverty via conserving, regenerating, upgrading, and equitably harnessing natural resources, particularly forests, pastures, and their links with crop lands—stemming from the contributions of these resources towards livelihood of the poor [Dasgupta (1996)]. These include direct

availability of firewood, fodder, fiber, food items, timber, medicinal herbs, honey, mushrooms, and vegetable dyes. The indirect services provided by forests and rangelands include better micro-environment and the flow of moisture and nutrients to sustain productive farming systems [Jodha (2003)]. The physical, economic, and ecological benefits of natural resources are not confined to the poor, but the poor do tend to depend more on nature-offered options. Unlike better-off groups, they do not have enough human-made endowments to support them [Agarwal and Narain (1990); Jodha (1992)].

Poverty alleviation and building of natural assets can be a two way process, i.e. natural resources to poverty alleviation or poverty first then natural resources. The second process is more applicable at the second stage (which may be operating in more rigorous manner) if the first phase is successfully run with empowerment zeal. The line of reasoning behind the Poverty Natural Resource Degradation Link (PNRD-L) is that poverty and scarcity cause desperation, which in turn promotes over-extraction of resources leading to resource degradation, causing still greater poverty and scarcity, it further accentuates this cycle. A major limitation of this formulation is its assumptions about the poor's approach to natural resources and their resource use behaviour. There are four implicit underlying reasons of depicting poverty as the prime mover of environmental degradation. First, the over-extraction of resources is the only and preferred means of sustenance that poor people know. Second, the poor are ignorant of the limitations of natural resources and consequences of their over-extraction. Third, the poor have little stake in the health and productivity of their natural resources. Finally, the poor have high rates of time preference (i.e. preferring present over future) and cannot afford to limit extraction [Jodha (2001)].

5. WHY IS EMPOWERMENT NEEDED FOR THE CAUSE OF POVERTY? AND HOW?

Experiences over the past few decades suggested many shortcomings in top-down approaches to development. Since 1980s, terms like participatory, community-led development [Mansuri and Rao (2004); Uphoff (1996)] and more recently empowerment are used in the development literature [Khwaja (2005)]. Empowerment has been conceptualised and defined in many ways. "*Empowerment broadly refers to the expansion of freedom of choices and action to shape one's life. It implies control over resources and decisions. For poor people, that freedom is severely curtailed by their powerlessness in access to both formal and informal institutions*" [Narayan (2005)]. Empowerment is an important source of enhancing the capacity of the individuals or groups to make purposeful choice, and transform them into outcomes through effective actions. Empowerment has intrinsic value and feelings such as self-confidence, walking with dignity, feeling respected, living without fear are indicators of empowerment. Empowering poor requires the removal of formal and informal institutional barriers [Narayan (2002)].

Kabeer (1999) asserted that empowerment is "*the expansion of people's ability to make strategic life choices in a context where this ability was previously denied to them*" (p. 437). This definition highlights both the actor's ability to make choices and the process of change in the achievement of this ability. In this definition, Kabeer (1999) emphasised the need to examine a poor group's resources, agency and achievements. The

World Bank's book on "*Empowerment and Poverty Reduction: A Source Book*" defines empowerment as "*the expansion of assets and capabilities of poor people to participate in, negotiate with, influence, control and hold accountable institutions that affect their lives*" [Narayan (2002)]. This definition is narrower and specific that what could be understood from the term "power" [Grootaert (2005)]. The World Bank book identifies four key elements of empowerment: (a) access to and/or provision of information, (b) inclusion/participation, (c) accountability, and (d) local organisational capacity [Narayan (2002)]. The access to and/or provision of information from external agents or organisation create the feeling of empowerment in depriving people/communities. The only pre-requisite is that both parties are willing to share the relevant information for achieving the desired goals. Participation is a mean of providing and gaining information. Participation not only helps assimilating information but also contain a component of welfare for the poor [Khwaja (2005)]. According to Uphoff (2005) six types of resources (i.e. economic, social, political, informational, moral and physical resources)[12] are needed for achieving the needs and wants at individuals and/or society.

About why empowerment is needed for the cause of poverty, there are several reasons that imply a need of empowering the poor for poverty alleviation:

1. An empowerment approach to poverty reduction is based on the conviction that poor are invaluable partners in development because they are the most motivated to move out of poverty. A growing body of evidence points to linkages between empowerment and development effectiveness at both society and grassroots levels [Narayan (2002)].
2. The social capital, the norms and networks enable collective action allowing increased access of poor to resources and economic opportunities. Poor often possess high social capital in terms of their bondages, close ties, trust etc. The only lacking element is limited physical resources [Narayan (1999); Woolcock and Narayan (2000); Grootaert and van Bastelaer (2002)]. They also lack in voice and power [Narayan (2005)].
3. Poor have good capacity to aspire,[13] which is a driving force for collective action.

[12]By *economic resources* means control over land, labour, capital as well as goods and services produced from them. It also includes income streams derived from wealth and assets. The *social resources* refer to social status or standing based on social roles or meeting socially valued criteria. These clearly affect one's ability to achieve one's goals. Social resources produce *services* in the form of respect, esteem and deference and are consumed in the form of *goods* like personal satisfaction, obtaining employment, respect from law enforcement officers etc. The *political resources* are primarily a consequence of the incumbency of authority role that entitle people to claim that they are speaking in the name of the state, community etc. and can potentially affect the domains of economic and social life with outcomes such as health care, employment, productivity enhancement and educational opportunity. The *informational resources* pertains to the knowledge than cane be production and beneficial in its own right and/or for others also. Such knowledge will off course be desired by others and a feeling of power comes from possessing. *Moral resources* means legitimacy accorded to decision makers, their role, the decision they make or the system of governance that leads people to defer to and accept other's decisions as right and proper. Legitimacy is a soft resource, conferring power based on highly subjective factors. The *physical resources* create physical force that people may be willing and able to exert against others to compel their cooperation or compliance. It is referred to as "coercion" if done with legitimacy claims and "violence" when it is not accepted as legitimate.

[13]Capacity to aspire is defined as the forward-looking capacity of individuals and groups to envision alternatives and to aspire to different and better future [Appadurai (2004)].

4. Empowerment approaches can strengthen good governance, which in turn enhances growth prospects. Development agenda containing the element of empowerment can more effectively promote pro-poor growth. This involves reducing inequalities by investing in poor people's capabilities through education, access to R&D institutions, access to land, financial capital, markets as well as educating them for the judicious use of natural resources today and caring to conserve for tomorrow.
5. In some instances, the successes in local empowerment efforts have created pressures for reforms at the regional and national levels [Grootaert (2005)].

The interactions among conditions in the empowerment process and the poverty alleviation outcomes are shown in Figure 4. The initial poor condition of resources, human capabilities and other deprivations determine the baseline empowerment conditions. The institutional support, service provision, policy backup and local participation leads to improving the empowerment of the local community. In this process local organisational capacities and institutional accountabilities also matters a lot because the shortcomings often distort the primary objective of local community empowerment. The improvements in the community empowerments can be observed in the form of better institutional access, access to information and technology, better understanding about natural resource utilisation, better resource productivity, better health, education, employment, infrastructure and income etc. This process is not as straight forward as it looks in Figure 4. The potential problems in implementation are discussed in the following section.

According to Uphoff (2005) empowerment is commonly understood as the condition of having power[14] and being able to exercise it and obtain the benefits thereof. Without having a valid understanding about what constitutes power, empowerment cannot be properly measured. Power implies towards need satisfaction while empowerment is more than satisfying needs. It is connected to people's wants and desires, things that affect their dignity, satisfaction, and personal fulfilment. The number of goods and services received is not a measure of empowerment.

6. IMPLEMENTATION PROBLEMS AND THE POSSIBLE SOLUTIONS

To make any natural resource conservation program successful, three elements are needed, i.e. proper addressing of the community stake, local control and the functional knowledge of natural resources rehabilitation and conservation. Addressing the community stake in natural resource during planning and implementation is central to their protection, development and equitable use. Reconciling the interest of diverse groups is a challenge involved in building the community's collective stake however

[14]Weber (1947) defined power as (a) the *probability* that someone *in a social relationship* will be able to achieve his or her *will*, that is, whatever is desired, despite *resistance* and regardless of the *bases* upon which this probability rests. Power is usually taken in absolute terms, reflecting whether an objective was achieved or not. It is more referred to effectiveness than efficiency. Thus power refers in most people's implicit lexicons to ex ante probabilities that a person can and will achieve what he or she wants. The poor people's general wants are food security, personal safety, stable income, shelter, clothing, health care, schooling for children, protection by the authorities against victimisation, equitable enforcement of law, respect, effective influence on public policy etc. [Uphoff (2005)].

Figure 4

focus on economic gains can be an effective tool. Achieving success in local control over natural resources, is another difficult task, however, it could be relatively easily achieved through obtaining confidence of various groups on equitable access to build up resource base. Half hearted attempts can harm the program any time during implementation[15]. In transferring functional knowledge about natural resources rehabilitation and conservation, it should be clearly understood that even regional and national level programs are basically implemented at local or micro level. Hence local perceptions should not be ignored or overlooked. According to Tamang, *et al*. (1996), the important factors obstructing the incorporation of indigenous knowledge in the interventions for natural resource development are arrogance and insensitivity of the planners towards local communities as a source of information to solve local problems leading to adopting top-down intervention approach.

One of the biggest challenges in measuring empowerment is that it is latent phenomenon. Its presence can only be deduced through actions or the results. Hence, most observed behaviours are proxies for some underlying phenomenon. Ten important challenges in measuring empowerment have been highlighted by Narayan (2005). These are: (i) empowerment has intrinsic value. It is an end in itself; (ii) it is universal as well as context-specific; (iii) it is individualistic and collective also; (iv) the level of application (e.g. individual, household, group, community, local/district, state or national government level) is very important for designing empowerment strategies; (v) it is multidimensional, i.e. it has not only economic dimension, other dimensions like social, psychological and political etc. are also important; (vi) origin and change; (vii) establishing causality; (viii) conceptual clarifications and linked measurements; (ix) clear delineation of measuring agency; (x) qualitative and quantitative methods of measurements applied.

7. SUMMARY AND SUGGESTIONS

Agriculture has now been seen differently than its conventional roles of supplying food/fibre and providing employment to increasing population. It is now considered an active partner in economic activities leading to overall development. In Pakistan, crop and livestock sub-sectors are equal contributor in total agricultural GDP. Unfortunately, in the past, the agriculture has been vastly underestimated for development. Agriculture is the only sector which is entirely dependent on the quality of natural resources for sustaining higher productivity. Those who exploited these resources for the development of the nation (i.e. the farmers), they themselves are now more suffering from vagaries of the nature like droughts, disease epidemics, low agricultural productivity and poor standard of living, all indications of poverty. They will remain operating in low input— low output domains of low efficiencies and sustained poverty impacts. Moreover, they will remain in poverty trap till the effective measures for the rehabilitation, regeneration and conservation of natural resources are not implemented. A more serious dimension of the issue is that these actual sufferers are not realising the severity of the issue in its true spirit, while the research and development institutions in public, private and NGOs working for the natural resources

[15]For instance, joint forest management programme in India where communities were involved in protecting resources but limited sharing on some products like timber and allowing to use intermediate products like fodder, fuel wood etc. were not successful [Jodha (2003)].

rehabilitation, regeneration, protection and conservation are operating under top-down approach. It is strange that these organisations are working for the farmers—the real custodians of natural resources and real affectee of poverty and productivity consequences—are least consulted during planning and implementation. In other words, they are least empowered in planning and implementation. Farmers' active involvement is desired because evidence shows that many technological interventions either did not worked or abandoned by the farmers after the withdrawal of institutional inputs/backup. While by becoming partners with development activities of their own areas, the farming communities can have more easy access to the problems' solution finding institutions as well as make the task of various institutions much easier. The primary objective of this paper is to sensitise the policy makers and development planners to create awareness and practice empowerment in development planning and implementation of plans and projects pertaining to natural resources conservation.

The salient points of the earlier discussions are again reiterated below.

- Pakistan ecology is mainly arid to semi arid. Abundant evidence verifies that the natural resources were unwisely over-exploited to achieve higher growth rates in agriculture. The country is now suffering from problems like water scarcity for crop cultivation with salinity and sodicity problems, more erratic and low rainfalls for rainfed agriculture and low carrying capacity of rangelands representing more three-fifth of total geographic area.
- In future, the crop sector will face new dimensions of the production problems and livestock sector may be more heavily depend upon rangelands while the current availability of fodder and crop remains/by-products are high insufficient.
- The farming community especially those living in the rainfed, marginal areas and desert ecologies are the real poor and are not aware of the poverty and declining productivity consequences of fast depletion of these natural resources.
- Planning and development authorities generally give low priority to development projects pertaining to natural resource rehabilitation and conservation, as their impacts cannot be measured in terms of direct economic returns.
- Large numbers of public, private and para-statal R&D institutions are working for the conservation and rehabilitation of natural resources under the top-down approach. There is lack of coordination and effective consultation of the farmers, the custodians of natural resources, in the planning and implementation.
- The review of literature clearly establishes that there is a linkage between poverty and natural resource degradation and poverty could be reduced by improving the quality of natural resources. There are also robust justifications available on how empowering farmers in the efforts of natural resources conservation and rehabilitation can help reducing poverty through more effective community mobilisation. The likely problems in community mobilisation are also highlighted with remedial measures.

The following suggestions are hereby forwarded for using empowerment as a tool by considering farmers to make them partners in natural resource rehabilitation and conservation for their productivity enhancement in order to alleviate poverty in these areas.

- The natural resource rehabilitation and conservation should be given high regards by the planning and development authorities by allocating substantial funds for such activities. At the same time, the partnership and empowerment aspects the development projects and proposals (or PC-1) should be specifically examined and ensured before approving such documents for funding. In other words, such projects should not be strictly evaluated on the conventional yardsticks of economic returns.
- Also, there should be high regards (in terms of additional allowances and relatively rapid promotion) to the people working for resource conservation.
- The bottom-up approach should be promoted rather than the conventional top-down methods in development planning and implementation.
- There should be some co-ordinating department at province level made responsible for careful scrutiny of the research, extension and development plans as well as maintains their mutual co-ordination.
- The print and electronic media should be used to create awareness among farmers about the detrimental consequences of unwise utilisation of agro-natural resources. They should also be educated on how to organise themselves for those common causes which directly affect their resource productivity, incomes and livelihoods. They should get due respect and participation in the research and development activities pertaining to the natural resources' conservation and rehabilitation in their areas.

Annexure 1

Land Capability Classes by Province in Pakistan

Items	Punjab (000 ha)	Sindh (000 ha)	NWFP + FATA (000 ha)	Balochistan (000 ha)	Northern Areas (000 ha)	Pakistan (000 ha)	Agricultural Potentials	Major Limitations
Class-1. Very good agricultural land	3,486.4 (16.9)	1,097.8 (7.8)	187.3 (1.8)	463.2 (1.3)	2.4 (0.03)	5,237.1 (6.0)	–Very high potential for general agriculture –Moderate potential for rice farming	–No significant limitation for general farming; –High permeability for rice cultivation
Class-2. Good agricultural lands	3,679.2 (17.8)	2,326.9 (16.5)	524.4 (5.2)	443.9 (1.3)	9.6 (0.1)	6,984.0 (8.0)	–Very high potential for general agric including rice provided it is mechanically tilled –High potential for general agriculture but low for rice –Very high potential for general agric. including rice, if reclaimed –Very high potential for general agriculture if properly drained	–Mainly clayee in nature, difficult to prepare seedbed, slow permeability causing surface ponding –Sandy/gravely soils cause undue loss of water and nutrients –Saline and sodic patches –Restricted aeration due to high water table with occasional ponding with rainwater
Class-3. Moderate agricultural lands	2,395.1 (11.6)	1,496.9 (10.6)	665.8 (6.5)	196.5 (0.6)	21.8 (0.3)	4,776.1 (5.5)	–Moderate potential for general agriculture and rice while low for pulses, sugarcane and orchards –Moderate potential for water loving & winter crops –Moderate potential for general agric. including rice, high potential when reclaimed –Moderate potential for rainfed agriculture	–Salinity and sodicity with no gypsum in the profile –Seasonal flooding by river and torrents –Severe salinity with gypsum in the profile –Low moisture availability from rains, sandy/gravely patches also present, moderate erosion hazards, unfavourable temperature regime
Class-4. Poor/ marginal agricultural lands	1,439.9 (7.0)	219.4 (1.6)	581.6 (5.7)	699.8 (2.0)	46.5 (0.6)	2,987.2 (3.4)	–Low potential for drought resistant crops –Good potential for some forest species	–Very low and erratic moisture from rains/torrents –Very sandy/gravely or shallow soils with erosion hazards
Class-5. Good forest or rangelands	0.0 (0.0)	0.0 (0.0)	70.1 (0.7)	0.0 (0.0)	101.1 (1.4)	171.2 (0.2)	–Low potential for forestry and range development	–No major limitation for forestry and range development
Class-6. Moderate forest/ rangelands	261.8 (1.3)	8.3 (0.1)	827.0 (8.1)	84.6 (0.2)	88.6 (1.2)	1,270.3 (1.5)	–Moderate scope for forestry and range development	–Slight erosion hazards –Sandy/stony/gravely soils –Low moisture availability Thus unfavourable for arable crops also

Continued—

Annexure 1—(*Continued*)

Class-7. Poor forest or rangelands	4,610.6 (22.4)	993.4 (7.0)	2,603.8 (25.6)	6,551.2 (18.9)	651.5 (8.9)	15,410.5 (17.7)	–Moderate scope for forestry and range development –Low potential for forestry and controlled grazing in rangelands	–Slight erosion hazards –Sandy/stony/gravely soils –Shallow soils, –Low moisture availability Thus unfavourable for arable crops
Class-8. Unproduc-tive/non-agricultural lands	4,159.7 (20.2)	2,714.7 (19.3)	2,974.0 (29.2)	10,599.1 (30.5)	2,749.8 (37.7)	23,197.3 (26.7)	–Mainly no potential for any type of economic agriculture	–Very sandy/stony/gravely/ shallow/patchy soils with low to high soil erosion –Snow/ice/glacier covers or permafrost conditions –Severe salinity/sodicity and very slow permeability –Extremely low and erratic moisture availability
Area suitable for arable use	11,000.6	5,141.0	1,959.1	1,803.4	80.3	19,984.4		
Area unsuitable for arable use	9,032.1	3,716.4	6,474.9	17,234.9	3,591.0	40,049.3		
Percent area suitable for arable use	53.3	55.7	21.4	9.4	2.2	32.3		
Percent area unsuitable for arable use	43.8	40.3	70.8	90.0	97.4	64.8		
Area Classified	20,032.7	8,857.4	8,434.0	19,038.3	3,671.3	60,033.7		
Total surveyed area	20,625.0	9,222.3	9,138.9	19,140.6	3,685.2	61,812.0		
% of total surveyed area classified	97.1	96.0	92.3	99.5	99.6	97.1		
Total geographical area	20,625.0	14,091.0	10,174.0	34,719.0	7,300.0	86,909.0		

Source: Mian and Mirza (1993).

Figures in parentheses are column percent representation of the area under respective soil class w.r.t. total geographic area.

Annexure 2

Vegetation Resources in Rangelands of Pakistan

Rangeland Type	Area (Million ha)	Location	Characteristics	Vegetations Available
Alpine pastures	1.68	- Kaghan valley, Gilgit,	- These areas lye above 3000 m and below the zone of perpetual snow. - The vegetation is mostly dominated by slow growing perennial, herbaceous and shrubby vascular plants and extensive mats of cryptogams (mosses, lichens etc.)	**Trees/Shrubs:** *Juniperus communis, Rosa webbiana, Berberis lycium, Berberis spp., Cotoneaster spp.* **Grasses:** *Phleum alpinum, Agrostis giganteam, Trisetum spp., Poa spp., Agropyron detatum, Agropyron caninum, Festuca ovina, Alopecurus giganteam, Dactylis glomerata, Pennisetum lanatum, P. filaccidum, Clamagrostis pweudophragmites, Oryzopsis spp. Carex spp.* **Forbs:** *Plantago ovata, Plantago major, Plantago lanceolata,Trifolium pratense, Trifolium repens, Fragaria vesca, Medicago spp., Potentilla spp. Rumex nepalensis, Polygonum alpinum, Anaphalis contora, Thymus serphyllum, Astragalus spp., Taraxicum officinalis, Iris hookariana, Nepata spicata, Saxifraga jacquemontiana*
Trans-Himalayan grazing lands	3.50	Dir, Chitral, Swat, Gilgit, Chilas and Skardu districts.	- Their altitude varies from 1500 to 8600 m and include 19 peaks over 7600 m. - Climate is bitterly cold winter and hot dry summer and it greatly varies with altitudes. - Average rainfall varies 100-300 mm. - Crop production, livestock farming and forestry are major land uses in the area. - Range ecologies can be divided into foothill ranges, dry temperate ranges, valley depression grazing lands, and alpine pasteures	**Trees/Shrubs:***Juniperus macropoda, Quercus ilex, Pinus gerardiana, Cedrus deodara, Pinus wallichiana, Frasinus xanthoxyloides, Artemisia maritime, Artemisia sacrorum, Indigofera spp., ephedra spp., Daphne oleoides, sophora spp., Cotoneaster spp., Parrotia jacquemontiana, Salix spp., jasminum spp., Sorbaria tomentosa Caragana spp.* **Grasses:** *Chrysopogon spp., Cymbopogon spp., Dichantium annulatum, Pennisetum orientale, Aristida spp., Oryzopsis spp., Poa spp., Bromus inermis, Agropyron dentatum, Agropyron canimum, Agrostis spp., Dactylis glomerata, Rottboellia exaltata, Phacelrus speciosus, Eragraostis spp.* **Forbs:** *Iris spp., Polygonum spp., Astragaslus spp., Sambucus ebulus, Lotus corniculatus, Medicago spp., Plantago lanceolata, Lathyrus spp., Thgmus serphyllum, Nepata spicata, Viola spp., Taraxicum officinalis, ferns etc.*
Himalayan forest grazing lands	0.67	Siran, Kaghan, Neelum and Jehum valleys	- It ranges from 1000-2000 m to the timberline. Jammu and Kashmir, Hazara, Kaghan, Shogran, Naran and Nathiagali. - Kail, deodar, spurs and fir forest are abundant here. - Crop production and livestock grazing are major land uses in the area. - Range ecologies can be divided into subtropical sub-humid zone, subtropical humid zone, temperate humid zone, sub-alpine zones, alpine zone, and glaciers/snowfields	**Trees:** *Pinus wallichiana, Picea smithiana, Taxus baccata Cedrus deodara Quercus dilatata, Quercus semicarpifolia, Juglans regia, Aesculus indica, Acer pictum, Acer caesium, populus alba, Populus ciliata, Pyrus sp.* **Shrubs:** *Vibermum nervosum, Indifera spp., Rosa webbiana, Salix spp., Catoneaster spp., Pistacia spp., Berberis lycium, Prunus cornata, Rhododendron arboreum, Sarococca saligna, Rubus spp., Desmodium spp., Strobilanthus spp.* **Grasses:** *Dactylis glomerata, Agropyron dentatum, Phacelurus speciosus, Rottboellia exalata, Alopecurus giganteam, Pennisetum flaccidum, Oryzopsis spp., Poa spp., Stipa sibirica, Bromus inermis, Bothriochola paseudoischaemum, Chrysopogon echineulatus, Themeda anathera* **Forbs:** *Plantago ovata, Plantago major, Plantago lanceolata, Senecio spp., Rumex nepalensis, Astragalus spp., Trifolium repens, Trifolum pratense, Lotus corniculatus, Fragaria vesica, Medicago spp., Geranium collinum, Geranium nepalensis, Thymus serphyllum, Polygonum aviculare, Polygonum parencoies, Phlomis bracteosa, Taraxicum officinalis.*

Continued—

Annexure 2—(*Continued*)

Pothwar scrub ranges	1.68	This tract lies between Jhelum and Indus Rivers and includes Attock, Islamabad, Rawalpindi, Chakwal and Jehlum districts	- It is ecologically sub-tropical semi-arid to sub humid. - The climate varies from temperate in the northeast to sub-tropical semi-arid in the southwest. - Annual rainfall varies from 250 mm in southern part of salt range to 1500 mm at Islamabad. - Temperature extremes at 45°C in June to below freezing during January. - Crop and livestock farming are major land uses	**Trees/Shrubs:** *Acacia modesta, Olea cuspidate, Zizphus mauritiana, Ziziphus nummularia, Salix tetrasperma, Dodonea viscose, Sageretia theezans, Gymnosporia royleana, Carissa spinarum, Adhatoda visica, Pistacia inegerrima, Nerium oleander, Otostegia limbata.* **Grasses:** *Chrysopogon monatus, Chrysopogon aucheri, Themeda anathera, Bothriochloa pertusa, Aristida mutabilis, Cenchrus ciliaris, Digitaria nodos, Desmostachya bipinnata, Imperarta cylindrical, Eleusine compressa, Cynodon dactylon, Panicum antidotale, Pennisetum orientale, Polypogon monspeliensis, Cymobopogon jawarancusa, Eulatiopsis binata*
Desert rangelands	7.97	These rangelands comprise Thal area of 2.6 million ha, D.G. Khan rangelands of 0.5 million ha, Cholistan rangelands of 2.7 million ha, Thararkar rangelands of 2.65 million ha.	Temperature extremes in Thal are 0-44°C and annual rainfall varies from 133 mm to 300 mm. Temperature extremes in D.G. Khan ranges varies 0-42°C and annual rainfall varies 72-162 mm. In Cholistan temperature ranges 0-40°C and annual rainfall varies 100-200 mm. In Tharparkar temperature extremes falls between 5-45°C and annual rainfall between 150-400 mm.	**Trees/Shrubs:** *Acacia jacquemontii, Acacia nilotica, Acacia Senegal, Calligonum polygonoides, Euphorbia caducifolia, Leptadenia pyrotechnica, Haloxylon recurvum, Haloxylon salicornicum, Kochia indica, Prosopis juliflora, Prosopis cineraria, Rhazya stricta, Salvadora oleoides, Salsoal foetida, Suaeda fruticsa, Tramarix aphylla, Ziziphus mauritiana, Ziziphus nummularia, Eleusine compressa,* **Grasses:** *Aristida depressa, Cenchrus biflorus, Cenchrus ciliaris, Cenchrus pennisetiformis, Cenchrus setigerus, Cymbopogon jwarancusa, Cenchrus schoenanthus, Cynodon dactylon, Desmostachya bipinnata, Dichanthium annulatum, Eleusine flagellifera, Lasiurus sindicus, Panicum antidotale, Panicum turgidum, Saccharum bengalense, Saccharum munja* **Forbs:***Aerva javaica, Aerva tomentosa, Crotolaria burbia, Indigofera cordifolia, Indigofera oblongifolia, Tribulus terristris, Tecoma undulata, Sporobolus sp., Aeluropus villosus, Demsmostachya bipinnata*
Kohistan ranges	2.38	It covers Karachi, Thatta, Dadu districts and pars of Lasbela district.	It is divided into three parts namely Kirthar range, Central Kohistan, Southeastern shield. Temperature ranges 3-45°C and annual rainfall 150-200 mm.	**Trees/Shrubs:** *Acacia nilotica, Acacia Senegal, Barleria acanthoides, Calotropis procera, Capparis aphylla, Commiphora wrightii, Commiphora stocksiana, Cordia gharaf, Euphorbia caducifolia, Grewia villosa, Leptadenia pyrotehnica, Lycium depressum, Pterophyllum oliverai, Prosopis cineraria, Ryazya stricta Salvadora oleoides, Tamarix dioca, Tecoma undulata,* **Grasses:** *Aristida adescensionis, Aristida mutabilis, Cenchrus ciliaris, Cenchrus Biflorus, Cenchrus pennisetiformis, Cynodon dactylon, Cymbopogon jwarancusa, Digitaria sp., Eleusine flagellifera, Lasiurus sindicus, Saccharum spontaneum, Sporobolus marginatus* **Forbs:***Aerva tomentosa, Cassia holosericea, Convolvulus glomeratus, Crotolaria bifolia, Fagonia critica, Heliotrpium ophioglossum, Indigofera oblongifloia, Rhynocosia minima*
Central Balochistan ranges	8.00	These ranges are spread over Quetta and Kalat divisions	Altitude ranges 1000-3000 m and mean annual rainfall 100-400 mm. Karez system of irrigation is prominent in the valley	**Trees/Shrubs:** *Cymbopogon choenanthus, Chrysopogon montanus, Juniperus macrooda, Pistacia sp., Fraxinus xanthoxyloides, Caragana ambigua, Prunus eburnean, Othonnopsis intermedia, rtemmisia scoparia, Haloxylon griffithii, Cousinia sp., Salsola sp., Tamarix sp.,* **Grasses:** *Cymbopogon schoenanthus, Withania coagulans, Acanthophyllum squarrosum, Calotropis procera, Caragana ulcinia*

Continued—

Annexure 2—(*Continued*)

Eastern Balochistan ranges	5.00	These are located in Zhob and Loralai districts of Balochistan	Bio-climate is influenced by summer monsoon rainfall.	The ranges here are grass dominated. Mainly of *Chrysopogon* species.
Western Balochistan ranges	18.50	It covers desert areas of Chagai, Kharan, Panjgur, Makran, Turbat, Gawadar and Lasbella districts	Rainfall ranges 50-200 mm.	In Chagai district, vegetation on the piedmont slopes consist of *Cousinia alepidea, Haloxylon griffithii, Alhagi camelorum, Saccarum ravannae*. In dunes and sandy areas, vegetation available are *Stipa plumose, Alheagi carnelorum, Tamarix sp. And Zhyphyllum atriplicoides.* The saline patches contain *Suaeda fructicosa, Salsoal sp., Panicum antidotale, Aelurophus repens and Aeluropus macrostachyus.* In Kharan district, piedonts have vegetations like *Prosopis cineraria, Salvadora oleoides, Capparis aphylla, Ziziphus sp.*. The saline paches have *Tamarix aphylla* and *Suaeda fruticosa.* In Lasbella district, *Prosopis juliflora* is also found. The main forage grasses found in the ranges are *Cenchrus ciliaris, Eleusine flagellifera, Pennisetum orientale, Artitida adscensionis.*
Sulaiman mountain ranges	1.50	This elongated area extends along Afghanistan border. The elevations range between 1540 and 3400 meters above sea level.	Annual rainfall range from 200 to 250 mm. Half of it is received in July-August.	**Trees/Shrubs:** *Acacia modesta, Acanthophyllum squarrosum, Berberis lyceum, Caragana ambigua, Caragana ulcinia, Daphne oleoides, Olea feruginea, Perowskia obrotonoides, Zhygophyllum atriplicoides,* **Grasses:** *Aristida funiculate, Aristida adscensionis, Chrysophogon montanus, Cymbopogon schoenanthus, Dactylactenium scindicum, Desmontachya bipinnata, Dichanthium annulatum, Pennisetum orientale, Saccharum ravannae, Stipa arabica* **Forbs:** *Ebenus stellatus, Cassia holosericea, Indigofera oblongifolia*
Total	50.88			

Annexure 3

Characteristics and uses of some trees and shrubs found in Thal desert of Pakistan

Common name	Botanical name	Characteristics	Uses
Trees			
Kikar	*Acacoa nilotica*	-Evergreen, Medium to Long size -Short trunk, Feathery foliage -Grows near rivers, flooded area and at banks of canals and water channels.	-Branches, leaves and pods used as fodder, bark used for tanning leather, wood for furniture and building material
Siris	*Albizia lebbek*	-large deciduous tree, spreading umbrella of feathery foliage & grows fastly. Seedling susceptible to shade, drought and frost (Khan 1965). Needs more water & tolerates brackish water.	-branches, leaves and pods used as fodder, wood for furniture, fuel and building material. Leaves and pods used as fodder, Provides shelterbelts to reduce wind speed.
Mesquite	*Prosopis juliflora*	-large crowned and deep rootedtree. Dark green leaves and long fleshy pods. Grows well onsandy soils. -10-18 m thorny tree with 60 cm diameter.	Leaves and pods as fodder. Fuel wood. Stabilise sand dunes. Used for making charcoal.
Jund	*Prosopis cineraria*	-leaves small & light green -desert tree & deep rooted. -grows throught Punjab and sind (Muhammad *et al*., 1984 and Sheikh 1986). Drought tolerant.	Leaves, pods and tender branches used as fodder. Fuel wood. Used for charcoal Stabilise and dunes. Timber for agricultural implements.
Iple-Iple	*Leucaena leucocephala*	-leguminous tree -Semi-evergreen with feathery leaves. -tall tree or a brandedshrub.	-leaves, pods and tender branches for fodder. Fuel wood. Timber for agricultural implements.
Frash, Ghaz	*Tamarix aphylla*	-fast growing tree, sheathed leaves. -erect trunk and rough bark. -Desert tree with high salt and drought resistance.	-Browsed by camels, goats and sheep. Timber used for handy-crafts, furniture and fruit boxes. Provides shelterbelts and wind breaks.
Ber	*Ziziphus mauritiana*	-Moderate size deciduous thorny, small tree. Short bole with spreading crown. height 5-8 m and diameter 30 cm. Highly drought tolerant. Tolerate extreme temperature. (-5 to 50°C)	-Branches and leaves as fodder. Bark for tanning leather & fruits. Leaves for silkworm -Timber for fuel, furniture and agricultural implements
Kikar	*Acacia jacquemontii*	An erect or bushy type deciduous shrub upto 9 ft. high	A good fodder for camel and goat. The branches cut and leaves thrashed out with sticks to be used as fodder.
Beri	*Ziziphus jujube*	Medium sized tree	Fruit edible, leaves used as fodder for Goat, Camel and Sheep and thorny branches for fencing.
Shrubs			
Phog, Pichungar, Terri	*Colligonum polygonoides* *Polygonaceae*	A rigid leafless shrub	A medium fodder browsed by cattle, goats, sheep and camels. Flower locally called "Phogoosy" are used as vegetable.
Khar, Surgal	*Haloxylon recurvum* *Chenopodiaceae*	A shrubby small plant	It is a common fodder for camel and goats.It is bunt for obtaining Sajji. (Soda ash)l
Khip	*Leptadinia spartium* *Asclepiadaceae*	Evergreen shrub up to2-3 ft. high.	Fodder for camel.
Wan, Pilu, Jal, Mithidiar, Jhar	*Salvadora oleoides* *Salvadoraceae*	A small much branched evergreen xerophytic tree	The fruit is described as beobstruent, carminative and diuretic. Roots are used as toothbrush. Leaves used as fodder for goats and camel.
Lani	*Salsola baryosma* *Chenopodiaceae*	Much branched, succulent, shrubby, herbs,	Fodder for camel.
Kali jani,Lana, Lunak	*Suaeda fruticosa* *Chenopodiaceae*	A much branched succulent shrub, 2 – 4 ft. high	A good fodder tor camel and goat, also good fire-wood.
Malla, Jher beri, kakan ber.	*Zizyphus nimularia* *Rhamnaceae*	Small size thorny xerophytic tree of shrub	Fruit edible, leaves used as fodder and thorny branches for fencing.
Bui, Irva, Tirf, Turf, Rah	*Aerva javamoca* *Amaranthaceae*	A much branched, broad leaved, erect, denselywhite, dioecious, perennial herb, often with woody basal parts.	Fodder for camel
Karir	*Cappris aphyllal* *Cappris deciduas*		Fodder for camel and fruit eaten by humane beings.
Chag	Crotolaria burhia Popilionaceae		Fodder for Goats

Source: Ali, *et al*. (2005).

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