Environmental Concerns in Pakistan, with Special Reference to Water and Forests

by

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INTRODUCTION

It is not an easy task to review comprehensively the state of the environment of any country in a limited number of pages, and the task becomes even more difficult and complex when data availability and reliability are serious problems. For a developing country such as Pakistan, ready availability of environmental data is a serious constraint for environmental management. However, there are two areas in which reasonable stores of data are available at present, and these are the water and forestry sectors, which are vital resources for Pakistan's satisfactory development. Accordingly, these are the principal sectors that will be analysed in this paper.

Pakistan has an area of 803,942 km^2, and its population at the time of the latest census in mid-1982 was 87.1 millions. In 1982–83, *per caput* gross income was Rs 4,176, or roughly US $320. Over the past three decades, the growth in GNP* averaged 5.5% per annum, with the population growing at 2.8% per annum and *per caput* real income growth at 2.6% per annum. The average life-expectancy at birth in 1980 was 50 years.

Despite a process of industrialization extending back to the foundation of the country in 1947, agriculture remains the core of the economy. In 1981–82, value added in agriculture accounted for 31% of GDP†, as compared with 24% for industry and 45% for services. Within agriculture, plant crops account for 66% of production, livestock for 31%, fisheries for 2%, and forestry for less than 1% of pecuniary production despite its vital importance for fuel-wood and in various other ways. The leading food-crop produced is wheat, which accounts for about 60% of cropped area and nearly 68% of the total food-grain tonnage. Rice is the second most important food-crop, accounting for some 17% of the cropped area. By 1981–82, the country was largely self-sufficient in grain production: in fact it was a net grain-exporter for some years during the nineteen-seventies, because of its exports of rice.

Since the first oil crisis, dependence on imports has risen from 14.4% of GDP† in 1972–73 to 21.2% of GDP by 1981–82, and exports have declined from 14.9% to 10.2% of GDP during the same period. The main factor facilitating support of the negative trade-balance has been remittances of Pakistanis working overseas, primarily in the oil-exporting countries of the Middle East. In 1981–82, overseas remittances reached $2,412 millions, which was higher than the total value of commodity exports of $2,319 millions. Thus one can argue that, overall, Pakistan has been a net beneficiary of any oil price increase.

* Gross National Product.

† Gross Domestic Product.

WATER MANAGEMENT

The climate of most of Pakistan is arid to semi-arid, having less than 200–500 mm of average annual precipitation. Distribution of the precipitation varies widely in terms of both space and time. The total precipitation is lowest in the south-west, but increases towards the north-east, and is at its highest in the Himalayan foothills where it may exceed 2,000 mm per annum. On the other hand, the precipitation is low in the mountain valleys of the north, occurring primarily as snow in winter. The seasonal distribution of precipitation is strongly influenced by the monsoons, which start in June or early July. The winter rains, however, may be less in quantity but generally more widespread and lasting. Because of such distribution characteristics, precipitation is generally inadequate for agricultural development based on rain-fed cultivation.

The average annual total river inflow is about 17.64 million hectare-metres (ha-m). The total drainage area of the Indus River is 944,500 km^2, of which 415,000 km^2 is outside the country. Under the Indus River Treaty of 1960, India has exclusive rights to all waters of the Ravi and Sutlej/Bias Rivers, leaving the Jhelum and Chenab Rivers for Pakistan.

Water quality of the rivers in Pakistan is generally good. Total dissolved solids (TDS) in the upper reaches range from below 100 ppm during high flows to about 200 ppm during low flows. Calcium and bicarbonate ions predominate. Water quality deteriorates downstream (TDS for Lower Indus ranges from 150 to 350 ppm), but still remains excellent for irrigation. TDS contents of tributary streams in more arid areas, however, are higher. Thus typical TDS concentrations range from 200 to 1,000 ppm in the perennial Gomal River, to 500–2,500 in the intermittent Lehri Nallah. Sodium and sulphate ions predominate in these rivers.

Sedimentation is a major problem in both major and minor rivers. Suspended sediment concentrations in major rivers range from a few ppm during low flows to 10,000 ppm during high flows. Sediment content of tributary rivers in arid areas can also be extremely high: for example, the highest sediment concentration observed in the Gomal River at Kot Murtaza has been 197,000 ppm.

Current observations indicate that more than 43,500 ha-m of suspended sediment enter the Indus System every year, but only about 18,500 ha-m pass Sehwan on the Lower Indus. This means that approximately 25,500 ha-m

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of sediments are deposited every year within the system, particularly in reservoirs and irrigation channels.

Water pollution from agricultural sources (fertilizers, pesticides, and drainage water) appears to be negligible at present in Pakistan. However, water pollution from industrial and municipal affluents has been growing, and has become a serious problem for rivers which drain large urban–industrial complexes, especially around Karachi, Lahore, and Faisalabad.

So far as ground-water is concerned, the entire Indus Plain is underlain by an unconsolidated, highly permeable alluvial deposit having a thickness of over 300 m in most places. Aquifer characteristics in the Indus Plain are highly variable. For example, the average specific yield of aquifers in Punjab is 0.17, but the corresponding figure is only 0.13 for those in Sind. Currently, it is estimated that ground-water is of good quality (less than 1,000 ppm of TDS) in 5.7 million ha of cultivated land, of moderate quality in 2 millions of such land, and of high salinity in 8.5 million ha (Planning Commission, 1983).

General Water Management

Water management in Pakistan has suffered because of the absence of appropriate government policy emphasis until recently. The principal preoccupation in the past has been the production of 'new' water. The Water and Power Development Authority (WAPDA) of Pakistan stated in 1979 that the 'emphasis on new water has been so dominant that serious concurrent efforts for water conservation, water use extension, and water scheduling for matching water supplies to crop water requirements, have not been made'. The Fifth Plan made a beginning by allocating some funds to water management, which were defined as the 'overall management of river supply, storages, and canal withdrawals'. Even then, however, WAPDA reported in 1979 that the 'subject has become so controversial that significant movement has not occurred'. Fig. 1 is a schematic diagram of the Indus Basin canal and irrigation system which serves much of the country.

In addition to the lack of appropriate policies in the past, there are several other constraints that help to explain the poor state of water management in Pakistan. The first is the institutional arrangements for the water sector. There is an

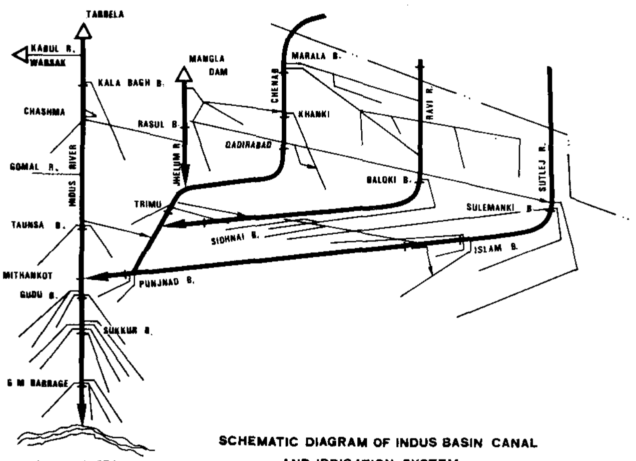

FIG. 1. *Schematic diagram of Indus Basin canal and irrigation system.*

urgent need to foster better communication and coordination than currently exist between the various agencies associated with the water sector, and to improve and strengthen the planning and implementation potentials of the Provincial Irrigation Departments—with clear delineation of the division of responsibilities between the various Federal and Provincial agencies.

Generally speaking, in Pakistan each institution basically performs its task in terms of its own partial objectives, and when these tasks are integrated nationally, the overall result is significantly less than optimal. Limited capacities and institutional deficiencies of the Provincial Irrigation Departments have also contributed to poor water management.

The second major constraint has been the lack of an overall agreement on the distribution of the water of the Indus System between the provinces. Continuation of an *ad hoc* decision on the allocation of surface water to the various provinces has contributed to inefficient water-use and has also created uncertainty about eventual water-rights. The following are among the difficulties which this problem has created:

i) provinces have been reluctant and/or slow to accept the fact that water losses in their delivery systems are high, as they are afraid that public exposure and acceptance of such losses may be construed as an acknowledgement of the need to reduce their demanded water requirements;

ii) provinces have attempted to increase irrigated areas in order to establish higher 'historical' levels of water use. This tendency can be noted even when additional water is not optimally used and/or contributes to salinity development and waterlogging;

iii) because of the uncertainty of the prevailing situation, farmers have been reluctant to make relevant on-farm investments required for optimal crop production.

All these constraints have contributed to many problems, of which the two principal ones are as follows:

A) Provincial governments have a strong tendency to view the water sector investment-choice process as an advocacy system to maximize the flow of resources to the provinces. This has resulted in distortions in investment choices. The provinces have a tendency to propose expensive, relatively low-priority capital projects, and to provide inadequate funding for projects which are aimed at improving the efficiency of the irrigation systems. For example, as the World Bank has pointed out, the choice between two investment options such as 'irrigation rehabilitation (a provincial responsibility) and drainage and reclamation (a federal responsibility) would not be made solely in terms of benefits and costs to the provinces (and nation) at the margin, but partly in terms of the additional (and "free") resources from the Federal ADP, the inflow of which should be maximized'.

B) The practice of focusing primarily on inputs has resulted in the present emphasis on maximizing the flow of resources through the capital budget, rather than on the eventual productivity of projects. In a perceptive analysis (WAPDA, 1979), the problem is clearly outlined as follows:

'WAPDA's charter is for planning and development of water resources; but its role in providing water supplies for irrigated agriculture is not clearly defined. Consequently, WAPDA plans and builds the water (and power) infrastructure, but does not concern itself with how the water is used and/or whether its investments are generating the estimated returns. That is taken to be somebody else's worry: nobody's at present. The Provincial Irrigation Department manages the canal system but not with the objective of generating returns from the huge investment already made. They see their job to be the efficient operation of the system from a hydraulic engineering viewpoint. They face serious difficulties in performing even this partial function because their operation and maintenance budget allocations have been declining in real terms (due to rapid inflation of the costs of maintenance but insignificant increases in revenues from water charges). No one at the federal level seems to be actively concerned about the current revenue deterioration, as the operation and maintenance expenditures are classified as 'current expenditures' and so are largely considered "provincial problems".'

On-farm Water Management

The total irrigated area in Pakistan increased from 12.99 million ha in 1971–72 to 14.79 million ha in 1981–82. While increase in the irrigated area was 13.8%, the quantity of irrigating water available at the farmgate increased by some 35% during the same period. The additional water available was utilized by:

i) practice of over-irrigation by the farmers as soon as additional water became available at low cost;

ii) changes in cropping pattern, e.g. growing of high-water-consumption crops; and

iii) use of additional cultivable land that had not been possible before within the same command area.

The total losses from Pakistan's overall irrigation system are very high. If the water balance for irrigation in the Indus Basin is considered, currently a total of 17.02 million ha-m of water is extracted, made up of 12.95 million ha-m of canal diversion and 4.07 million ha-m of ground-water (Fig. 2). Losses in conveyance, watercourses, and application, reduces this to 5.58 million ha-m, which is consequently available for actual irrigation. Thus, about two-thirds of water originally extracted is lost by various means.

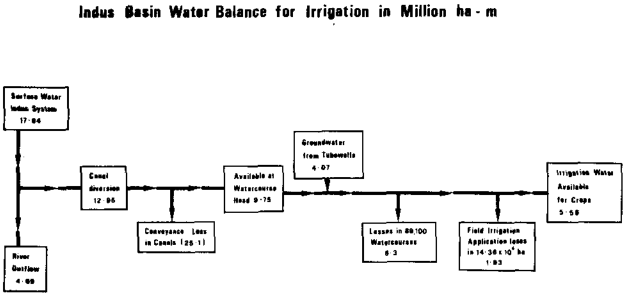

FIG. 2. *Schema of Pakistan's Indus basin water-balance for irrigation, in million hectare-metres.*

The maximum loss occurs from watercourses and totals an estimated 6.3 millions, which is more than the water available for crops.

Irrigation planning in the nineteen-sixties assumed watercourse losses of the order of 10–15%. However, studies in the nineteen-seventies indicated the actual losses to be some three times the assumed value, at 45% (Table I). Losses occurred primarily due to seepage, leakage, and spillage, and were not necessarily higher in watercourses in coarse-textured than in fine-textured soils. This is because a large component of the loss is due to leakage and spillage, while in coarse soils any fine sediments can have a useful sealing effect. As watercourses have little or no freeboard or space between their lows and highs of water-levels, spillage losses are significant, especially in SCARPs* (Table I), where discharge from the tube-wells is added to the canals. This is because, generally, expansions of watercourse capacities were not included in SCARPs 'under the expectation that the necessary improvements [would] be made by the farmers'.

In order to improve the water delivery and use, a pilot on-farm water management project was initiated in 1976–77, which essentially involved the improvement of watercourses by adding some 10–15% more lining, installation of 40 *pucca nakkas* (concrete control structures) per watercourse, precision land-levelling, and training of personnel. Though the pilot programme did not achieve the targets

* This acronym stands for Salinity Control and Reclamation Project.

TABLE I
Results of Study of G1 Watercourses (WAPDA, 1979; Ashraf, 1982).

	Delivery Efficiency (%)		*Application Efficiency (%)*		*Irrigation Efficiency (%)*	
	Rabi	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*
All 61 watercourses studied	55	56	70	68	38	38
Provinces:						
NWFP & Punjab	58	61	73	69	42	42
Baluchistan & Sind	45	44	64	65	29	29
Canal Type:						
Perennial	55	56	72	71	40	40
Non-perennial	54	50	63	60	34	34
SCARP*	44	44	70	69	31	30
Non-SCARP	56	58	69	67	39	39
Private Tubewells	62	64	78	74	48	47

* Salinity Control and Reclamation Project

set, it did create a realization among the farmers of the importance of on-farm water management.

At present, there are several constraints, in addition to the institutional ones mentioned earlier, which are making the impact of on-farm water management far less effective than it could be. Among the principal constraints are the following five:

(i) Many people in the Federal and Provincial Irrigation institutions are unwilling to accept that losses in the delivery system are high. When some senior bureaucrats openly state that they believe the losses mentioned earlier are not representative and/or not accurate, it is bound to have an effect on the middle and lower echelons of bureaucracy. To some extent, the professed scepticism can be explained by the fact that, as the losses in the irrigation system are significantly higher than they were expected to be, the bureaucrats concerned are unwilling to accept them, as this might appear to be an indirect criticism of their running of the institution. This attitude is prevalent not only in Pakistan but in other countries as well.

(ii) Engineers, in general, do not consider work in connection with operation and maintenance as exciting. The brighter and more competent ones tend to gravitate towards design and construction of major works, such as dams and canal systems. In addition, as on-farm water management requires extensive periods of sojourn in rural areas, and professionals tend to gravitate towards jobs in major urban centres, recruitment of suitable candidates is not an easy task. The bureaucratic red-tape for recruitment further aggravates the situation.

(iii) While on-farm water management is providing limited information on how best to use the water to increase agricultural production—because of a lack of adequate extension services on water use. WAPDA (1979) reports that 'few farmers know how much water is required for good plant growth, most have no knowledge about stages of growth when irrigation is critical, and few farmers check the sub-soil to determine when to irrigate'.

(iv) Land levelling is not making commensurate progress to use water efficiently.

(v) The *warabandi** system of water distribution is based on the fundamental assumption that flow-rate in the watercourse is the same at the head, middle, and tail, reaches. When the system was developed, losses during conveyance were not considered to be significant. Accordingly, equitable distribution of running-time was considered to be synonymous with equitable distribution of water. Because of high losses in watercourses, however, the *warabandi* system is providing an inequitable distribution of water, a much higher quantity going to the farms at the head than at the tail.

Finally, it is essential that watercourses which have been improved under the on-farm water management programme be maintained, so that the benefits will continue to accrue on a long-term basis.

* In answer to our question about the meaning of this term, the Author replied that it 'means water supply to farmers on a rotating basis'.—Ed.

Drainage and Reclamation

Because of the gentle slope of the Indus Plain (only 0.2 m per km), drainage has been a major problem dogging local irrigation development. Both salinity and waterlogging were recognized as major problems in *doaba* (areas between rivers) by the end of the nineteenth century.

When Pakistan became independent in 1947, only a few canals were lined, and 3,700 km of drains were in operation. Some 40,000 ha of fertile irrigated lands were going out of production every year owing to salinity and waterlogging (Bokhari, 1980). In 1953, C.D. Carlston identified three main factors as being responsible for the rising water-table and the resulting waterlogging and salinity: leakage from the irrigation and distribution system, infiltration of applied irrigation waters, and, to a lesser extent, increased recharge from runoff due to the obstruction of natural drainage courses (Carlston, 1953). Recent studies indicate that some 80% of the aquifer recharge is due to leakage and infiltration, and the remainder is contributed by run-off discharge, link canals, and the rivers (Johnson, 1982).

Serious attempts have been made to eradicate salinity and waterlogging during the past two decades, but the results of these attempts have been somewhat mixed. The present status of the surface-salinity profile is shown in Table II.

The first Salinity Control and Reclamation Project (SCARP I) was initiated in 1960 to serve 485,000 ha of land in Rechna Doab, an interfluvial area between the Ravi and Chenab Rivers. The main objectives of SCARP I were to

TABLE II

Surface-salinity Profile in Percentages.

Province	*Total**	*Saltfree*	*Slightly Saline*	*Moderately Saline*	*Strongly Saline*	*Misc. Land Type*
Baluchistan	100 (353,416)	74	17	5	4	**
NWFP	100 (614,008)	78	5	2	2	10
Punjab	100 (10,164,857)	84	7	4	3	2
Sind	100 (5,579,108)	50	19	10	18	3
TOTAL	100 (16,711,389)	72	11	6	8	3

* Figures in brackets show total areas in ha.
** Less than 1%.

TABLE III

Progress of Drainage Projects under SCARP.

Type	*Gross Area (10^6 ha)*	*Tube-wells* *Number*	*Tube-wells* *Capacity (m^3/sec)*	*Surface Drains (Length in km)*
Tube-well Drainage:				
Fresh Ground-water	3.09	12,875	999	—
Saline Ground-water	0.77	2,016	103	—
Total	3.86	14,891	1,102	—
Surface Drainage:	1.85	—	—	5,500
Grand Total	5.71	14,891	1,102	5,500

demonstrate the effectiveness of vertical drainage by tube-wells in order to lower the water-table over a large area, provide additional water for irrigation, and to leach out salts and so reclaim saline soils.

Completed in 1963, SCARP I indicated that tube-wells can be effectively used to lower ground-water over a large area. Accordingly, additional projects were undertaken. Currently about 35 projects, large and small, have been implemented under the SCARP programme, as shown collectively in Table III (Badruddin, 1982).

Ex-post analyses of the SCARP programme have revealed several technical and management errors (Bokhari, 1980; Johnson, 1982), which were further aggravated by unanticipated increases in energy costs. Another major problem arose as a result of the lack of participation by farmers.

Early reclamation and salinity control programmes were carried out with full government subsidy, without the farmers making any financial or physical contributions. The new reclamation philosophy developed by WAPDA* and its foreign consultants in the 1960s anticipated that the farmers of the Indus Basin, who were mostly illiterate and had smallholdings, would modernize their land and water management practices automatically and thus optimize agricultural production from the farms. Furthermore, the farmers were expected to pay back the capital and running costs of the projects.

There was a lack of participation of the farmers during the planning of the project, and lack of understanding by the planners of the behavioural attitudes of the farmers to such projects. As a result, the farmers did not consider it worth participating in and contributing to sustain what they considered to be a purely public-sector programme, the maintenance of which they saw as a moral duty of the Government. As Bokhari (1980) has noted that 'it was too optimistic to assume that just to consume poor-quality ground-water, poor farmers of the Indus Basin would beg, borrow or steal money and technology to renovate their land and water management practices spontaneously'. In addition, use of pumped out, poor-quality saline ground-water increased the soil salinity as a result also of the primitive farming practices that were employed. Thus, many small farmers felt that the government programme ran against their private interests.

The Sixth Plan has recognized many of the problems associated with the SCARP Programme. The total allocation for the drainage and reclamation sector under the Sixth Plan is Rs 13,815 millions, which is 43% of the total allocation for the water sector, and constitutes a 245% increase over the Fifth Plan expenditures for drainage and reclamation. This is essential, as the Accelerated Drainage Programme managed to reclaim only 30% of the target areas during the Fifth Plan, when 60% of the total allocation went to high expenditures for the Tarbela Dam, where 243% of the national allocation was spent.

The Sixth Plan will concentrate on reclamation measures in those endangered areas where ground-water is within 1.52 m (5 ft) of ground-level. Priority will be given to the areas underlain by saline ground-water. The reclamation of fresh ground-water, where crop cultivation is possible, would be left to the private sector. Credits, subsidies, and provision for electricity, will be supplied to the private sector, to encourage tube-well installation. This means a new policy decision of *not* sanctioning new SCARPs in areas of fresh ground-water, which would now be left to the private sector.

* Water and Power Development Authority.

TABLE IV

Types of Energy Used for Lighting and Cooking by Housing Units, 1980 (Population Census Organization, 1982).

	Total *Housing Units in 10^6*	*Total* *%*	*Urban* *Housing Units in 10^6*	*Urban* *%*	*Rural* *Housing Units in 10^6*	*Rural* *%*
Source of Lighting						
Electricity	3,849	31	2,525	71	1,324	1
Kerosene	8,463	67	990	28	7,474	8
Other	275	2	40	1	235	
Cooking Fuel Used						
Wood	8,810	70	1,714	48	7,096	7
Coal	87	1	46	1	41	
Kerosene	781	6	714	20	66	
Gas	813	6	786	22	27	
Electricity	11	—	4	—	7	
Cow-dung, etc.	2,086	17	291	8	1,796	2

Rural Energy

Rural energy in Pakistan is dominated by kerosene for lighting, and wood, cow-dung, and agricultural residues, for cooking. Kerosene is a popular source of energy in rural Pakistan. Some 83% of rural households use it for lighting but only abut 10% for cooking. Kerosene costs 1.5–2 times the retail price of fuel-wood in Pakistan. If Pakistan's entire fuel-wood consumption were to be replaced by kerosene, the total cost would be more than Rs 9 thousand millions per year. Furthermore, as fuel-wood is an indigenous product but kerosene has to be imported, this hypothetical displacement would represent a substantial drain on Pakistan's balance of payment problem.

Table IV shows that 20% of rural households use cow-dung and agricultural residues—presumably when adequate quantities of fuel-wood are not available to meet their domestic energy requirements. Replacements of the use of fuel-wood by cow-dung would contribute to different types of development problems. For example, if it were possible to replace the entire fuel-wood use in Pakistan with cow-dung, the loss of nutrients by the soil would be significant. It has been estimated that the farmers would have to add over Rs 3.2 thousand millions worth of fertilizer to make-up for the fertility-loss which would occur under such a scenario (Department of Forestry, Wildlife and Fisheries, Punjab, 1983*a*). In any event, current uses of agricultural wastes and cow-dung are significant, equivalent to about 12 millions m^3 of fuel-wood annually.

Amongst agricultural residues, the most commonly used as fuel is cotton sticks. In 1981–82, 2.276 million ha of land was under cotton cultivation (Economic Advisor to the Government of Pakistan, 1983). This is likely to produce 3.02 million tons of cotton sticks. If it is assumed that 90% of the cotton sticks are used as domestic fuel, the total amount is equivalent to 2.2 million m^3 of fuel-wood.

The energy supply situation differs substantially in urban areas, where 71% of the housing units use electricity for lighting and 42% use conventional cooking fuels such as kerosene (22%) and gas (28%). Use of gas in Pakistan has risen rapidly in recent years, as it is not only a clean source of fuel (no smoke) but also its price has been kept artificially low. Current prices of gas are only about one-third of the equivalent amount for fuel-wood or oil, or one-fifth the price of kerosene. In spite of such pricing policies, however, more than half of the urban households (56%) still used wood, cow-dung, or agricultural residues, for cooking in 1980.

While much progress has been made in Pakistan during the past 35 years in rural electrification, the present status of development is far from ideal. In 1959, only 609 villages were electrified. Viewed purely in terms of the number of villages that are electrified, the results are impressive. Currently, out of about 45,000 villages listed in the 1972 census, some 16,400 have been electrified, and about half of these were electrified in recent years. In addition, some 114,000 tube-wells have been electrified. The agricultural sector at present accounts for 18.4% of all electricity consumption (Planning Commission, 1983).

If, however, the number of beneficiaries are considered, the performance seems far less satisfactory. On an overall basis, only about 25% of the population in electrified villages in Pakistan have access to electricity. For the country as a whole, this translates to only about 8% of the rural population.

Fuel-wood Availability and Use

Very little information is available at present on the demand and consumption patterns of fuel-wood in Pakistan. The absence of reliable data should not, however, be construed to mean that fuel-wood is not an important factor in Pakistan, either economically or socially. On the contrary, it is a vital component for survival, especially in rural areas for cooking and, in certain areas, also for heating. Some very rough estimates are available (Amjad & Mohammad, 1982) which clearly indicated its importance.

Fuel-wood accounts for as much as 90% of all wood consumed in Pakistan (Draper *et al.*, 1978). According to the Pakistan Household Census of 1980, 79% of the rural, and 48% of the urban, households use fuel-wood for cooking. If cow-dung and agricultural residues are added to fuel-wood, together they account for 99% of rural and 56% of urban cooking fuel requirements. Fuel-wood alone also provides for nearly 50% of the total energy requirements of the domestic sector of the country, the balance being provided by fossil fuels (13%) and agricultural residues and cow-dung (37%): (Pakistan Forest Institute, 1983). Draper *et al.* (1978) estimate the present fuel-wood consumption rate at around 0.2 m^3 *per caput* per annum. Accordingly, with a population figure of 88.22 millions as of January 1983 (Economic Advisor to the Government of Pakistan, 1983), Pakistan's present annual consumption of fuel-wood can be estimated at around 17.65 million m^3. At the present average retail price of fuel-wood of Rs 27 per maund (1 maund = 37.324 kg), this amount of fire-wood would represent a total annual contribution to the country's GNP of some RS 5.5 thousand millions, if all fuel-wood transactions were carried out commercially. Even at a low on-farm value of fuel-wood of Rs 10 per maund, the total annual fuel-wood production of Pakistan is worth over RS 2.0 thousand millions. But high though these figures are, they do not necessarily convey a complete perspective on the role and importance of fuel-wood.

Even if estimates of fuel-wood availability and use are very preliminary, it is evident that, as Pakistan's population increases, fuel-wood demands are likely to go up as well, at least for the next two decades. Experiences from Pakistan and other developing countries of the region indicate that, as people move up the economic scale, their preference generally shifts to better-quality fuel. Thus, during the next two decades the penetration of non-wood fuel into Pakistan is likely to increase. In spite of such a shift, the Pakistan Forest Institute (1983) has estimated that, by the year 2000, the country's fuel-wood requirements are likely to increase to 30 million m^3 per annum. The Sixth Five-Year Plan expects the fuel-wood demand to rise to 20.2 million m^3 by the end of the Plan period, 1988.

While demands for fuel-wood have been increasing, its overall resource-base appears to be shrinking. It has been estimated that the annual growth of wood in Pakistan is approximately 11.3 million m^3 (Department of Forestry, Wildlife and Fisheries, Punjab, 1983*a*). Assuming an annual timber production rate of 1.10 million m^3, and an annual fuel-wood consumption rate of 17.65 million m^3, it

TABLE V

Extent of Forest Areas, 1970–80.

Province/ Territory	Total Area (10^6 ha)	Forest Area (10^6 ha)	Forest as % of Total Area	Forest Area per ca in ha
Baluchistan	34.72	0.72 (1.07)	2.07	0.23
NWFP	10.17	1.08 (0.67)	10.62	0.08
Punjab	20.63	0.59 (0.43)	2.86	0.01
Sind	14.09	0.59 (0.58)	4.19	0.03
Northern Area	7.04	0.94	13.35	1.77
Azad Kashmir	1.16	0.38	30.29	0.19
TOTAL—PAKISTAN	87.81	4.30	4.90	0.05

means that the present annual growth of wood accounts for only about 62% of the total annual wood harvest. If these estimates are at all reliable, it can only mean that Pakistan's total inventory of wood resources has been declining in the recent past, and seems likely to decline still further in future.

Increasing demand for fuel-wood and a shrinking resource-base have meant that fuel-wood prices have increased sharply in recent years. For example, the average annual retail prices of both fuel-wood and charcoal nearly doubled during only one year, between 1972–73 and 1973–74, in all state-capital cities of Pakistan. The wholesale prices of fuel-wood increased by 4.5 times during the period 1969–70 to 1979–80. Expressed differently, fuel-wood and timber prices increased, respectively, 44% and 120% faster than the general price increases during this period.

The scarcity and increasing prices of fuel-wood have a special relevance to the energy requirements of the rural poor. Since fuel-wood, agricultural residues, and cow-dung, account for nearly all the cooking energy requirements of the rural poor, any shortages and/or rapidly increasing prices will have serious implications for their welfare. While a significant percentage of the present cooking energy requirements in rural areas is obtained non-commercially, commercial transactions in fuel-wood can now be seen in most villages of Pakistan. With increasing fuel-wood prices, the extent of commercial trading is likely to increase in the future, which in turn could aggravate the plight of the rural poor.

At the present fuel-wood prices, an average Pakistani family, which has to purchase all its fuel-wood for cooking, would have to pay up to Rs 1,100 per annum. When compared with their annual income, this amount is extraordinarily high. Furthermore, this amount does not include fuel-wood requirements for heating for part of the winter in areas where this is necessary.

Forest-poor Country

The problem is that Pakistan is a forest-poor country. Of the total land area of 87.81 million ha, 10.1 million ha are under the control of government forest departments. This includes 6.1 million ha of rangelands which do not contribute to wood production. Thus, the actual area under forests is 4.3 million ha, which accounts for about 4.8% of the land area of the country. Of these, 3 million ha are productive forests and 1.3 million ha are protective forests. The *per caput* forest area in 1979–80 was only 0.05 ha. The forest areas of different provinces and territories are indicated in Table V, and the extent of forest areas occupied by particular vegetation-types can be seen in Table VI (Pakistan Forest Institute, 1983). Fig. 3 shows the nine major vegetation zones of the country.

The average growth-rate per ha per annum in coniferous forests is 0.62 m^3, in irrigated plantations 4–10 m^3, and in riverine forests, 1.6 m^3. The growing stock of forests under government control is estimated at 238 million m^3, 170 million m^3 being in coniferous forest and 68 million m^3 in broad-leafed forests.

While production of fuel-wood in state forests is important, even more important is production from private farms, as those account for over 90% of the total production. Furthermore, small farmers and landless workers tend to use non-commercial forms of fuel-wood—those that grow on their own land and/or those that can be collected at no financial cost within a reasonable distance from their homes. As fuel-wood produced from state forests is for sale, rural poor are not its primary customers, except perhaps for that which is obtainable by unauthorized means.

There is no doubt that fuel-wood production from farmlands can be increased significantly. For example, in Punjab, according to a social forestry survey, the average number of trees per acre is only three (Department of Forestry, Wildlife and Fisheries, Punjab, 1983*a*). This latter agency estimates that the number of trees in farmlands can be increased to about 30 per hectare (12 per acre) in the irrigated and rain-fed areas of the province—an increase of 300% over the existing situation—without detriment to the agricultural crops. As Punjab has a total irrigated area of 10,492 million ha and a rain-fed area of 0.98 million ha, the potential for social forestry in the province is enormous.

TABLE VI

Forest Areas by Type of Vegetation.

Type of Vegetation	Area in Million ha	Percentage of Total
Coniferous	1.78	41.4
Scrub	1.72	40.0
Riverine	0.29	6.8
Coastal	0.28	6.6
Irrigated Plantations	0.20	4.5
Others	0.03	0.7
Total	4.30	100.0

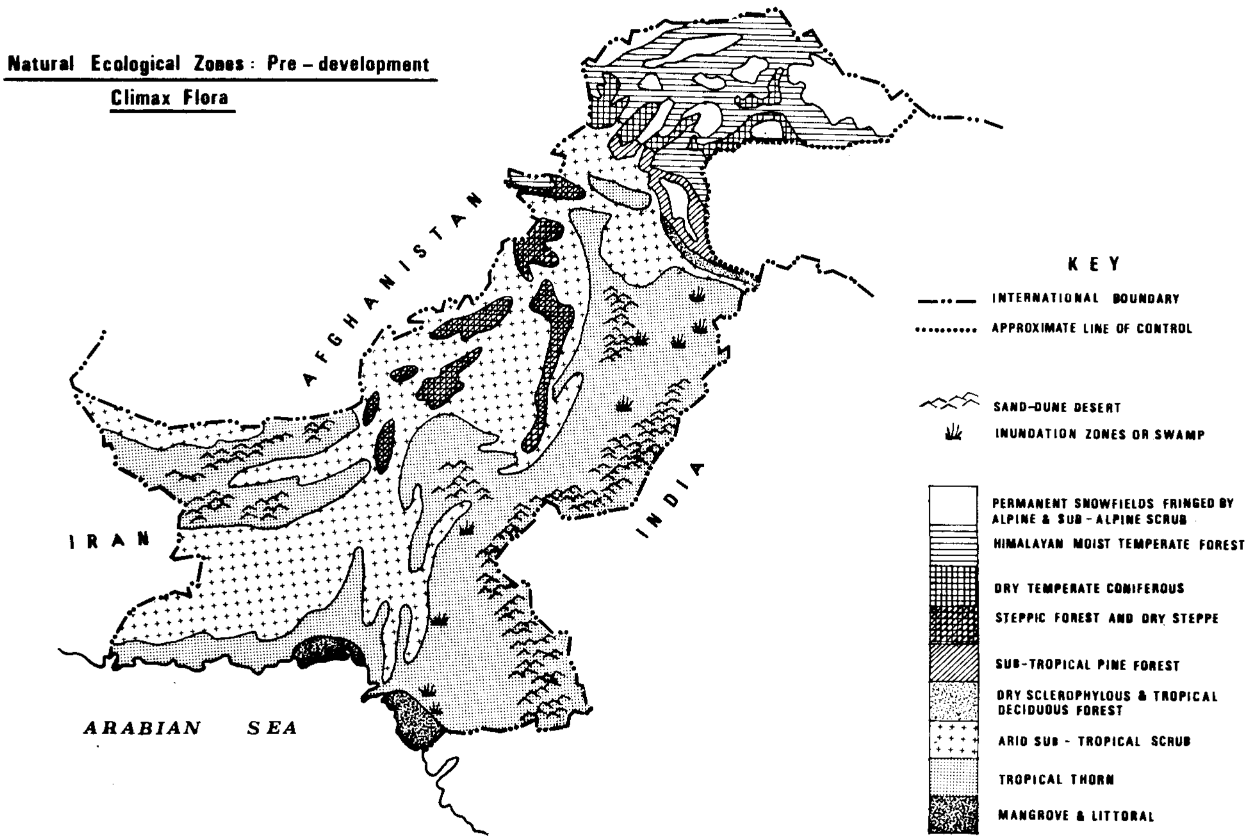

FIG. 3. *Sketch-map of Pakistan showing natural ecological zones of pre-development climax vegetation (after Pakistan Forest Institute).*

The fuel-wood problem in Pakistan, as in most other developing countries, has not yet received adequate attention. To some extent this can be explained by the fact that the powerful and high-visibility section of the urban elite and wealthy classes have easy access to convenient cooking media such as coal or kerosene. The real urgency of the problem has thus far not permeated through to the policy-making quarters. The PCI document for the Forestry Planning and Development project sums up the present situation as follows (Department of Forestry, Wildlife and Fisheries, Punjab, 1983*b*):

> 'At present, Pakistan's federal and provincial decision-making bodies are not well-positioned to make wise decisions regarding the development of Pakistan's forest and fuelwood resources. They do not have the data nor analytical information necessary to judge the merits of forest and fuelwood developments against those of importance in other sectors. Similarly, they lack the information necessary to determine which specific investments in forest and fuelwood development will make the most desirable contributions to the federal and provincial development. Finally, the forestry institutions of Pakistan lack the basic knowledge of farm and energy forest systems and the experience in applying them, both of which are essential to reversing the decline in the nation's productive forest base'.

If prices of fuel-wood continue to increase in real terms, as in the past decade, it is likely to account for an increasing share of the household expenditure of the rural poor. If the present agricultural development trends continue, there is a real danger that the country may be self-sufficient or even an exporter of many food grains by the end of this decade, but that the rural poor may not have adequate fuel-wood to cook their food.

Other Rural Energy Sources

Electricity:—An analysis of energy consumption in the agricultural sector of Pakistan indicates that electricity consumption in agriculture steadily increased latterly at a compound growth-rate of 11% per year. Present indications are that the popularity of electricity in the agricultural sector will continue to increase in the foreseeable future.

The Pakistan Atomic Energy Commission, however, has estimated (Jameel, 1981) that use of electricity in the sector will increase from 180 MW in 1977 to only 450 MW by the year 2000. The question therefore arises, how can electricity be provided to rural areas of Pakistan on a sufficient scale for agricultural and other purposes? It has a special relevance when the criteria for selection of villages for electrification are considered. These criteria are based primarily on the distances of villages from the high-tension transmission lines—a distance that is at present fixed at 0.5 mile (0.8 km), except in Baluchistan. This means that many villages having large populations, if not situated within a distance of 0.5 mile from existing or proposed transmission lines, will have very little hope of getting electricity, even though they might offer a more economical and efficient use of the energy because of their relatively large population base and also in terms of potential uses.

It is thus essential to consider decentralized forms of energy which can be used in such villages for electricity generation and other purposes, and which could also be used effectively in the existing electrified villages—especially in terms of improving the coverage of beneficiaries in the lower-income strata. Various possibilities are biogas, solar energy, and small-scale hydro projects.

Biogas:—A rough estimate of the potential of biogas production can be made on the following assumptions. The number of cattle *plus* the buffalo population in 1980 amounted to some 25 millions. Assuming 18 millions of these to be three years old or more, and with 50% dung collectability, 90 millions kg of dung may be available daily for biogas production. This would generate about 1,215 million m^3 of gas per annum, which can be valued at Rs 2,260 millions. Furthermore, biogas slurry has a high nitrogen content and can be used as fertilizer.

Biogas units have thus far been constructed, primarily for development and demonstration purposes, for both family and community uses. For a family of 5–6, a 100 ft^3/day (*c.* 2.83 m^3) unit would be adequate to provide the energy necessary for cooking and lighting. Such a unit, requiring dung from 5–6 cattle, would replace about 2,000 litres of kerosene per year. Larger community biogas plants (capacity, 2,000–5,000 ft^3/day) would be of special interest in rural energy-deficient areas. These plants, if so desired, can be designed to make priority provision for bio-electrification and rationed provision for cooking. Few community biogas plants have, however, so far been constructed.

Solar Energy:—Some interesting developments have occurred very recently for harnessing solar energy for rural development. Pakistan's first solar village, at Mumniala near Islamabad, is now in operation (Elliott, 1983), and the second one, at Kankoi in Swat, has now been commissioned. Another 6–10 villages, away from the national grid system, are to have solar photovoltaic systems in due course. A Silicon Technology Development Centre was established in Islamabad in April 1981, with the assistance of the United Nations, to carry out research and development work in photovoltaics.

An important development so far has been in the area of solar pumps for irrigation. Since March 1981, 20 solar-powered micro-irrigation pumps have been tested in Pakistan by ADBP, PARC, and Intermediate Technology Industrial Services (ITIS), through three growing-seasons. Eighteen of the pumps consisted of two panels of silicon cells, producing 250 watts at peak to drive an integral pump and motor. Assuming a local temperature of 30°C, these units were estimated to deliver 160 litres per minute with a 4 m lift. During field trials, they achieved nearly 80% of that capacity (Intermediate Technology Development Group, 1982).

The potential for developing biogas, solar energy, and small-scale hydro projects, is significant in Pakistan. The appropriate technology development organization of the Government has estimated that some 30% of energy requirements of rural Pakistan can be met from these sources, for a potential saving of nearly US $300 millions per year of kerosene import. Assuming that only half of such a saving materializes, it would still be a substantial sum. Overall, it would be fair to say that, in Pakistan as widely elsewhere, renewable energy sources—with the exception of large-scale hydro ones—have not received anything like the attention which they deserve.

Conclusion and Summary

The state of the environment and its proper management is a prerequisite condition for the sustainable development of any country, and Pakistan is no exception.

Thus, availability of appropriate quantities of water and energy on a reliable basis in Pakistan is essential for improving the quality of life. This means that the policies formulated and actions taken must ensure that the developments taking place should not endanger the overall resource and environmental bases of the country, on which the development process itself depends. Currently, some serious environmental problems exist in Pakistan in terms of salinity development, waterlogging, and inefficient water-use, in the water sector, and deforestation in the energy sector—especially so far as fuel-wood availability is concerned. Furthermore, deforestation in the upper reaches of the catchment areas is contributing to high sediment-loads in the rivers of Pakistan, which in turn is reducing the reservoir capacities and their designed economic lives.

For a country that now has only limited sites for construction of new reservoirs, and a serious balance-of-payments problem, it is essential that existing resource-development projects be managed in an environmentally-sound manner, so that an adequate quantity of water is available on a long-term basis for both irrigation and hydroelectric generation. Similarly, deforestation issues need to be tackled on a realistic basis, as the problem will not disappear unless people have access to alternative sources of energy at prices which they can afford to pay.

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