chapter 1

Introduction: Pakistan and its Salinity Problem

Overview

This chapter focuses on the critical question of why Pakistan needs 'saline agriculture' at all. We begin by introducing the landscape, population, climate and irrigation system of Pakistan and then discuss the factors affecting the development of soil salinity and waterlogging. Finally we examine the social and economic consequences of salinity for Pakistan's people.

The land

Pakistan covers an area of about 800 000 square kilometres. The country contains six major landscape units: the northern mountains, the Hindu Kush and western mountains, the Potwar Plateau and Salt Range, the Baluchistan Plateau, the Indus Plain, and the Cholistan and Thal deserts.

The people

The current population is about 135 million. This will double in the next 20 years, placing acute pressure on land resources.

The climate

Except for a narrow belt in the north, the whole of Pakistan has an arid to semiarid climate with a low and variable rainfall. For most of the country, most rain is monsoonal. There are two annual cropping seasons, the *kharif* season (for summer crops like rice) and the *rabi* season (for winter crops like wheat).

The irrigation system

For most of the country rainfall is too low and irregular for cropping. Irrigation is therefore used on about three-quarters of the cultivated land. Irrigation water is supplied from the canal system and by pumping groundwater.

The salinity and waterlogging problem

Land salinisation is a major cause of desert formation in Pakistan. About 6.3 million hectares are affected. Secondary salinity is caused by seepage from irrigation canals, high salt concentrations in irrigation water, insufficient leaching of salt, and the use of irrigation water with a poor salt balance.

The impact of salinity on the community

Communities affected by salinity are acutely economically deprived. This impacts on the quality of family life, the incidence of illiteracy, access to health care, and the ability to purchase household goods.

1.1 The Land[1]

Pakistan covers an area of about 800 000 square kilometres, stretching about 1600 kilometres from north to south and about 900 kilometres from east to west. The country contains six major landscape units (see Fig. 1.1).

- *The northern mountains*, which comprise the western ranges of the Himalayas. These are a series of parallel mountain ranges with deep broad valleys between. The ranges include the Siwaliks (heights of 500 to 1000 metres), the Outer Himalayas (average heights of about 3000 metres), the Central Himalayas (average heights of about 5000 metres), and the Karakorams (which include K2 with a height of 8610 metres). These mountains are the source of Pakistan's major rivers.
- *The Hindu Kush and the western mountains*, which form the boundary between Pakistan and Afghanistan. The highest mountain (Tirich Mir) is 7690 metres high.
- *The Potwar Plateau and Salt Range*, which lie between the Indus and the Jhelum rivers, south of the northern mountains. The Potwar Plateau is highly dissected and has an average elevation of about 500 metres. The Salt Range consists of a steep face of bare rocks rising about 700 metres out of the Punjab Plain.
- *The Baluchistan Plateau*, which comprises most of the Province of Baluchistan. This plateau has an average elevation of about 600 metres and consists of ranges of dry hills (generally running from north-east to south-west), dry valleys, saline lakes and vast areas of desert.
- *The Indus Plain*, which covers an area of about 21 million hectares and is the most prosperous agricultural region of Pakistan. It extends about 1000 kilometres from the Peshawar Vale, the Bannu Basin and the edge of the Potwar Plateau to the Arabian Sea. Its northern zone comprises the Province of Punjab and parts of North West Frontier Province, while the southern zone forms part of the Province of Sind. The Indus Plain is extremely flat; it has an average gradient towards the sea of only 19 centimetres per kilometre (Ghassemi et al. 1995, p. 370).
- *The Cholistan and Thal deserts*. The Cholistan Desert lies to the south-east of the Indus Plain on the border with India. The Thal Desert lies between the Indus and the Jhelum rivers. The deserts have salt lakes in their depressions.

Pakistan's major river is the Indus, which has an annual flow of 115 billion cubic metres (Ahmad and Chaudhry 1988, Table 3.2). It originates on the Tibetan plateau at an altitude of about 5500 metres above sea level and flows south to the Arabian Sea. The major tributaries of the Indus are the Chenab (flows 32 billion cubic metres), the Jhelum (flows 28 billion cubic metres), the Sutlej (flows 17 billion cubic metres), the Beas (flows 16 billion cubic metres) and the Ravi (flows 9 billion cubic metres). These join with the Indus in the Upper Indus Plain (Fig. 1.1). As a consequence, the Upper Indus Plain is divided into a number of *doabs* (meaning the land lying between two rivers). The Bari, Rechna and Chaj doabs lie between the Sutlej and Ravi rivers, the Ravi and Chenab rivers, and the Chenab and Jhelum rivers respectively.

1.2 The People

Although there has been no census of the Pakistan population since 1981,[2] we can use historical data to estimate the number of people presently in the country and the likely trend in population growth for the future.

Four national census surveys have been conducted in Pakistan since independence (1951, 1961, 1972, 1981). Figure 1.2 shows that the population growth in the period 1951–81 was about 3% per year. If a similar rate of population growth holds for the period after 1981, then the estimated population at the present time (1997) is about 135 million, and this number will double by the year 2020. This population growth will place enormous pressure on land resources in Pakistan.

About 68% of the population lives in rural areas. Agriculture is the largest and most important sector of Pakistan's economy. It accounts for about one-third of the gross domestic product and generates about two-thirds of Pakistan's total foreign exchange earnings.

The number of people affected by saline, sodic and/or waterlogged soils in Pakistan is not known. We estimate that about 16 million people are presently directly affected and that this number will also double by the year 2020.[3]

1 These notes have been adapted from Ahmad and Chaudhry (1988), Sandhu and Qureshi (1986) and Ghassemi et al. (1995).

2 The possibility of a new national census was being widely canvassed in the media at the time of writing.

3 This estimate is based on the following assumptions:
(a) the present population of Pakistan is about 135 million people, (b) about 68% of these people live in rural areas, (c) about 70% of rural dwellers live in irrigated areas, and (d) about 25% of irrigated land is salt affected or waterlogged.

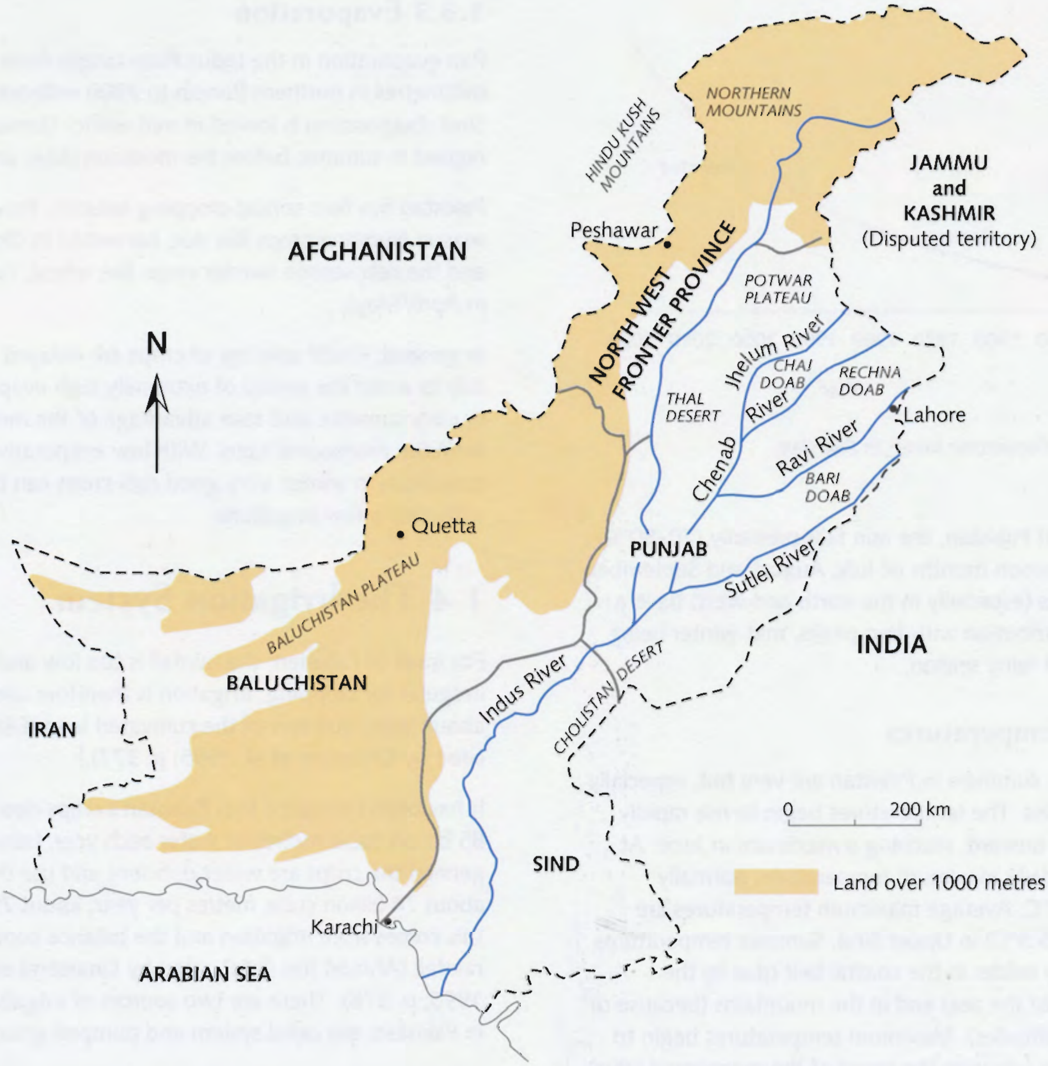

Figure 1.1. *Major landscape units of Pakistan (Ahmad and Chaudhry 1988).*

1.3 The Climate[4]

1.3.1 Rainfall

The whole of Pakistan (except a narrow belt in the north) is arid to semiarid and has a low, variable rainfall (Fig. 1.3). Annual precipitation is highest (around 1500 millimetres) on the southern slopes of the Himalayas and gradually decreases to the south-west. Only 9% of the country receives more than 508 millimetres (20 inches) of rain per year. A further 22% receives between 254 and 508 millimetres, and about 69% receives less than 254 millimetres (10 inches) of rain per year.

As in all arid areas, the pattern of rainfall can be quite variable. In the drier south-western areas, cases have been recorded when a single day of rain has far exceeded the long-term annual average.

4 These notes have been adapted from Ali (1971) and Ghassemi et al. (1995).

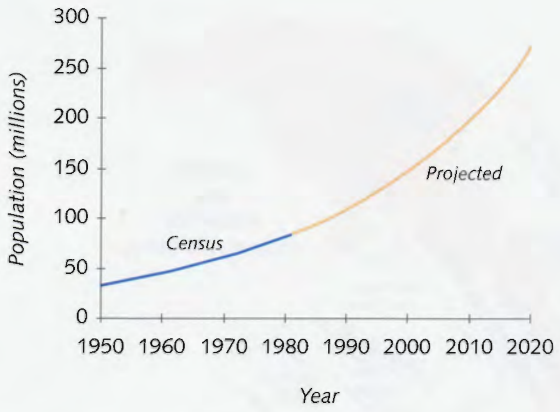

Figure 1.2. *Population trends in Pakistan.*

For most of Pakistan, the rain falls primarily (70–80%) in the monsoon months of July, August and September. Some areas (especially in the north and west) have a rainfall distribution with two peaks, mid-winter being the second rainy season.

1.3.2 Temperatures

In general, summers in Pakistan are very hot, especially on the plains. The temperatures begin to rise rapidly from April onward, reaching a maximum in June. At this time, daily maximum temperatures normally exceed 40°C. Average maximum temperatures are highest (45.5°C) in Upper Sind. Summer temperatures are slightly milder in the coastal belt (due to the proximity of the sea) and in the mountains (because of the high altitudes). Maximum temperatures begin to decrease in July with the onset of the monsoonal rains.

Winter is very severe in the mountainous regions of Pakistan. Temperatures close to freezing are common in January and February, and temperatures can fall to –6°C to –12°C. In the plains, winter temperatures are higher; the average minimum temperature in January for much of the Indus Plain is about 4°C. Frost is common for at least a few weeks in late December and January in all areas except for a narrow strip along the coast.

1.3.3 Evaporation

Pan evaporation in the Indus Plain ranges from 1300 millimetres in northern Punjab to 2800 millimetres in Sind. Evaporation is lowest in mid-winter (January) and highest in summer, before the monsoon (May and June).

Pakistan has two annual cropping seasons, the *kharif* season (summer crops like rice, harvested in October), and the *rabi* season (winter crops like wheat, harvested in April/May).

In general, *kharif* sowings of crops are delayed until July to avoid the period of extremely high evaporation in early summer, and take advantage of the moisture from the monsoonal rains. With low evaporative conditions in winter, very good *rabi* crops can be raised with only a few irrigations.

1.4 The Irrigation System

For most of Pakistan, the rainfall is too low and irregular for cropping. Irrigation is therefore used on about three-quarters of the cultivated land (FAO 1989, cited by Ghassemi et al. 1995, p. 377).[5]

It has been estimated that Pakistan's crops need about 85 billion cubic metres of water each year. However, in general the crops are water deficient and use only about 78 billion cubic metres per year; about 79% of this comes from irrigation and the balance comes from rainfall (Ahmad [no date], cited by Ghassemi et al. 1995, p. 378). There are two sources of irrigation water in Pakistan: the canal system and pumped groundwater.

1.4.1 The canal system[6]

The most important source of irrigation water is the Indus River System.

Irrigation canals in Pakistan date back to the fourteenth or fifteenth century (Common Era), but the extensive irrigation structures that exist today have been constructed in the course of the last 140 years.

The early canals, built during the reign of the Moghul emperors, were inundation canals without weirs, designed to take water from cuts in the rivers. They carried water only when the rivers were high and were rather unpredictable in operation. They were also subject to frequent breaches and serious silting problems.

5 In 1987, the Food and Agriculture Organization estimated that about 20.76 million hectares in Pakistan were under cultivation. Of this, 16.08 million hectares were irrigated and 4.68 million hectares were non-irrigated (FAO 1989).

6 This material has been derived primarily from the account by Ali (1971), pp. 17–18. More detailed information is available in the monumental book by Ahmad and Chaudhry (1988).

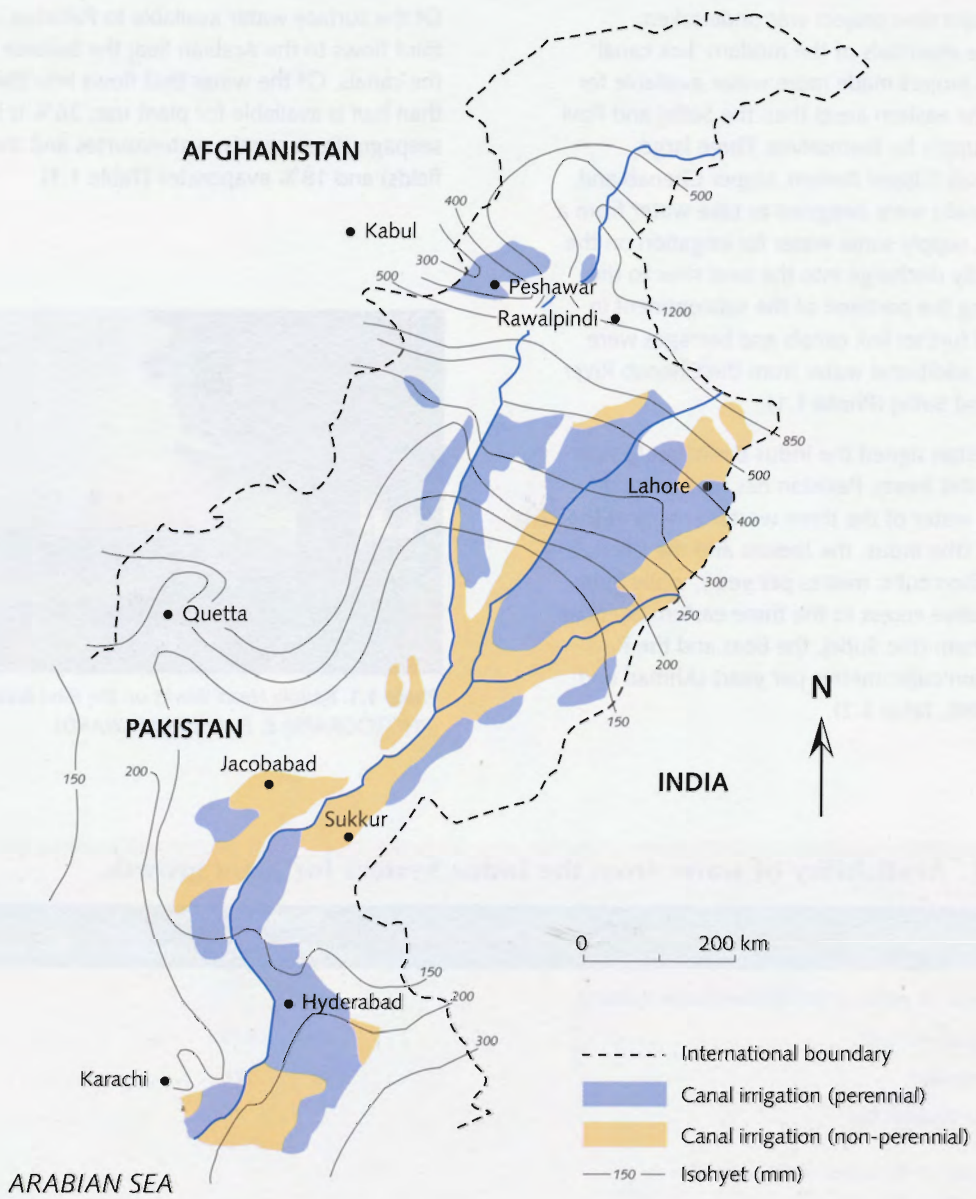

Figure 1.3. *Average distribution of rainfall in Pakistan (Badruddin 1987, cited in Ghassemi et al. 1995, Fig 8-3, p. 379).*

The first major modern canal developments on the subcontinent were the Upper Bari Doab Canal (opened 1859), the Western Jumna Canal[7] (opened 1871) and the Sirhind Canal (opened 1872). All of these are now in India. In the late 1870s, severe famine occurred in the northern Indus Plain. The British government responded with a substantial program of further canal development in the area that now lies in Pakistan. By about 1900, modern irrigation canals commanded about two million hectares of land in the Punjab and Peshawar Vale (Ali 1971, p. 17).

7 This canal was originally constructed by Feroze Shah Tughlak in the fourteenth century, and was reconditioned and extended by Akbar and Shah Jahan. It was restored by British engineers in the period 1817–25. A decision was made to realign the canal following an outbreak of malaria in 1851 caused by seepage (Ahmad and Chaudhry 1988).

In 1905, a major new project was undertaken, containing the essentials of the modern 'link canal' concept. This project made more water available for irrigation in the eastern areas than the Sutlej and Ravi rivers could supply by themselves. Three large regulated canals (Upper Jhelum, Upper Chenab and Lower Bari Doab) were designed to take water from a western river, supply some water for irrigation on the way, and finally discharge into the next river to the east. Following the partition of the subcontinent in 1947, several further link canals and barrages were built to bring additional water from the Chenab River to the Ravi and Sutlej (Photo 1.1).

In 1960, Pakistan signed the Indus Basin Treaty with India. Under this treaty, Pakistan has had exclusive access to the water of the three western rivers of the Indus system (the Indus, the Jhelum and the Chenab — about 175 billion cubic metres per year), while India has had exclusive access to the three eastern rivers of the Indus System (the Sutlej, the Beas and the Ravi — about 42 billion cubic metres per year) (Ahmad and Chaudhry 1988, Table 3.2).

Of the surface water available to Pakistan, about one-third flows to the Arabian Sea; the balance flows into the canals. Of the water that flows into the canals, less than half is available for plant use; 36% is lost as seepage (from canals, watercourses and the farmers' fields) and 18% evaporates (Table 1.1).

Photo 1.1. *Balloki Head Works on the Ravi River. [PHOTOGRAPH: E. BARRETT-LENNARD]*

Table 1.1. Availability of water from the Indus System for plant growth.

	Volume of water (billions of cubic metres)	Percentage of total
A. What happens to water of the Western Indus System?		
Total flow through system[a]:	175	100
• flows into canals[b]	126	72
• flows to the Arabian Sea[c]	49	28
B. What happens to the water in the canals?		
Total flows into canals:	126	100
• seepage of canal water out of canals, watercourses and farmers' fields[d]	42	33
• evaporation of canal water out of canals, watercourses and farmers' fields[e]	18	14
• water for plant use[f]	66	52

a Annual flow averaged for the period 1922–61 (Ahmad and Chaudhry 1988, Table 3.2)

b Canal withdrawals averaged over 8 years (from 1977–78 to 1984–85 — Ahmad and Chaudhry 1988, Table 4.4)

c Calculated as total flow minus canal withdrawals

d There are a number of estimates of seepage of surface water in Ahmad and Chaudhry (1988). The figure used here is the Water and Power Development Authority estimate (Ahmad and Chaudhry's Table 5.30) and is the sum of the figures quoted for 'canals' and 'watercourses'.

e Calculated from Ahmad and Chaudhry (1988), Figure 5.50

f Calculated as flows into canals minus seepage minus evaporation

1.4.2 Groundwater

The aquifer beneath the Indus Plain is recharged by about 54 000 million cubic metres of water each year (Ahmad and Chaudhry 1988, Table 5.30). This recharge comes from the seepage of rainfall, river water and water from the irrigation system. In order to satisfy irrigation requirements, about 44 billion cubic metres of this groundwater is pumped from public and private tubewells (Ahmad, no date, cited by Ghassemi et al. 1995).

Rivers are a major source of recharge to the groundwater. Therefore, proximity to rivers can have a large effect on groundwater salinity. These effects can be seen in both plan view (Fig. 1.4) and in cross-sectional view (Fig. 1.5). In general, close to the rivers, the groundwater is relatively non-saline to considerable depth; in contrast in the mid-regions of the *doabs* there may be little or no available non-saline groundwater. In general, the quality of groundwater deteriorates as one crosses the Indus Plain from upstream to downstream and to the Arabian Sea.

1.5 The Salinity and Waterlogging Problem

Land salinisation is one of the major desertification processes in Pakistan;[8] about 6.3 million hectares are affected.[9] About half of this lies in the Canal Command Area.[10] Apart from a few localised areas, salt-affected soils are confined to the Indus Plain (Photo 1.2).

Salt has always been part of the Pakistan environment. The Indus Plain is composed of alluvial sediments, which were deposited by rivers into a shallow sea. The receding sea has left behind residues of salt, both in the soil profile and in the groundwater aquifer. In addition, weathering of parent rocks can release significant amounts of salt into the soil.

Accumulation of salts at the soil surface is characteristic of arid and semiarid environments, especially where irrigation is practiced. Salinisation occurs both naturally ('primary' salinity) and as a result of human activities ('secondary' salinity).

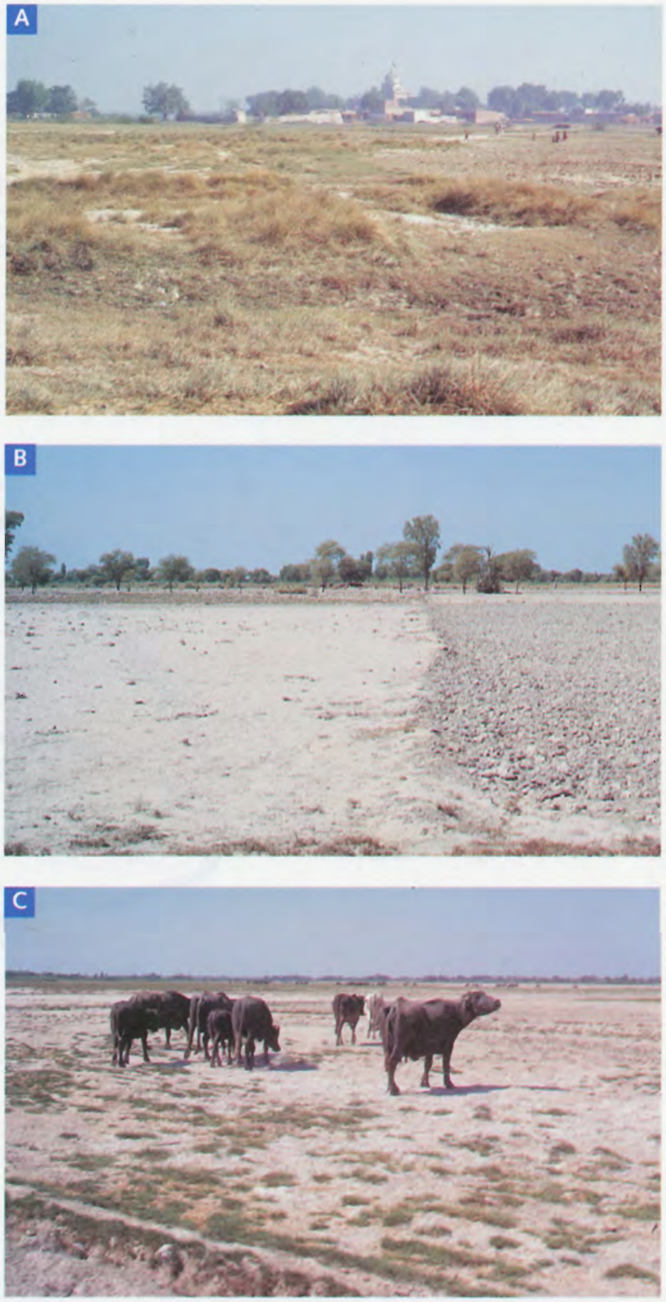

Photo 1.2. *Three views of salt-affected land on the Indus Plain. (A) Abandoned wasteland near Lahore. (B) Salt-affected land tilled for cropping near Faisalabad. (C) Buffalo grazing salt-affected land at Satiana. [PHOTOGRAPHS: E. BARRETT-LENNARD]*

8 The link between salinisation and desertification has been established through publications such as United Nations (1989). It is also recognised in antidesertification projects that focus on saltland (e.g. United Nations Development Programme 1997).

9 The statistics regarding the area affected by the problems of salinity and waterlogging in Pakistan are controversial. Estimates of the area of salt-affected land have differed widely because of different criteria of classification and methods of survey used by various agencies (see reviews by Sandhu and Qureshi 1986; Qureshi 1993; Ghassemi et al. 1995). The figure of 6.3 million hectares quoted here is based on similar outcomes from two of the most recent accounts (Government of Pakistan 1988; Khan 1993).

10 Rafiq (1990) estimated that 54% of salt-affected land is within the Canal Command Area. The area of salt-affected land in the Canal Command Area is therefore $(6.3 \times 0.54) = 3.4$ million hectares. The Canal Command Area totals 15.8 million hectares; the salt-affected area therefore accounts for 21% of this.

Figure 1.4. *The relationship between groundwater salinity and proximity to rivers. The isohyets show the average salinity of the groundwater to a depth of 110 metres in the Upper Indus System (Rathur 1987, cited in Ghassemi et al. 1995, Figure 8-2, p. 375).*

Primary salinity on the Indus Plain occurs around the margins of natural depressions in the landscape where rain and floodwater accumulate. These soils become loaded with salts because of the movement of water by capillarity to the soil surface. Land affected by fossil salinity is generally severely saline and is not easily reclaimed.

Secondary salinity on the Indus Plain is all related to the development of the modern irrigation system in Pakistan. There are four causes of secondary salinity.

- *Seepage from irrigation canals.* Before the development of the major irrigation canals in the Indus Plain, watertables were about 30 metres deep (Fig. 1.6). However, watertables substantially increased following the development of major irrigation canals in the late-nineteenth century. These increasing watertables brought salt stored deep in the profile to the soil surface.

- *High salt concentrations in irrigation water*. As noted in Section 1.4.2 above, the quality of groundwater can be highly dependent on proximity to the major rivers. Many soils of the mid-regions of the *doabs* have become saline–sodic because of the use of saline groundwater for irrigation.
- *Insufficient leaching of salt*. All irrigation water contains salt that can accumulate in the root-zone over time. Whether this occurs depends on rates of water application. If water is always applied in quantities just sufficient for crop use, then salt will accumulate in the root-zone. However, if there is an occasional heavy application of irrigation water, then the salt in the root-zone will be leached deeper into the soil profile. It is important to remember that salt accumulation in the root-zone may occur even with the application of good quality canal water. The salt concentration in canal water in Pakistan is generally between 150 and 250 milligrams per litre (Ghassemi et al. 1995, p.380). The application of 500 millimetres of water with a salinity of 200 milligrams per litre would add 1 tonne of salt per hectare. With continued irrigation and no leaching, this salt could build up with time. Of course the scale of the problem of salt accumulation in the root-zone is even greater if saline groundwater is used for irrigation.
- *Types of salts in the irrigation water*. Saline–sodic soils have occurred to some extent through the use of irrigation water with high concentrations of

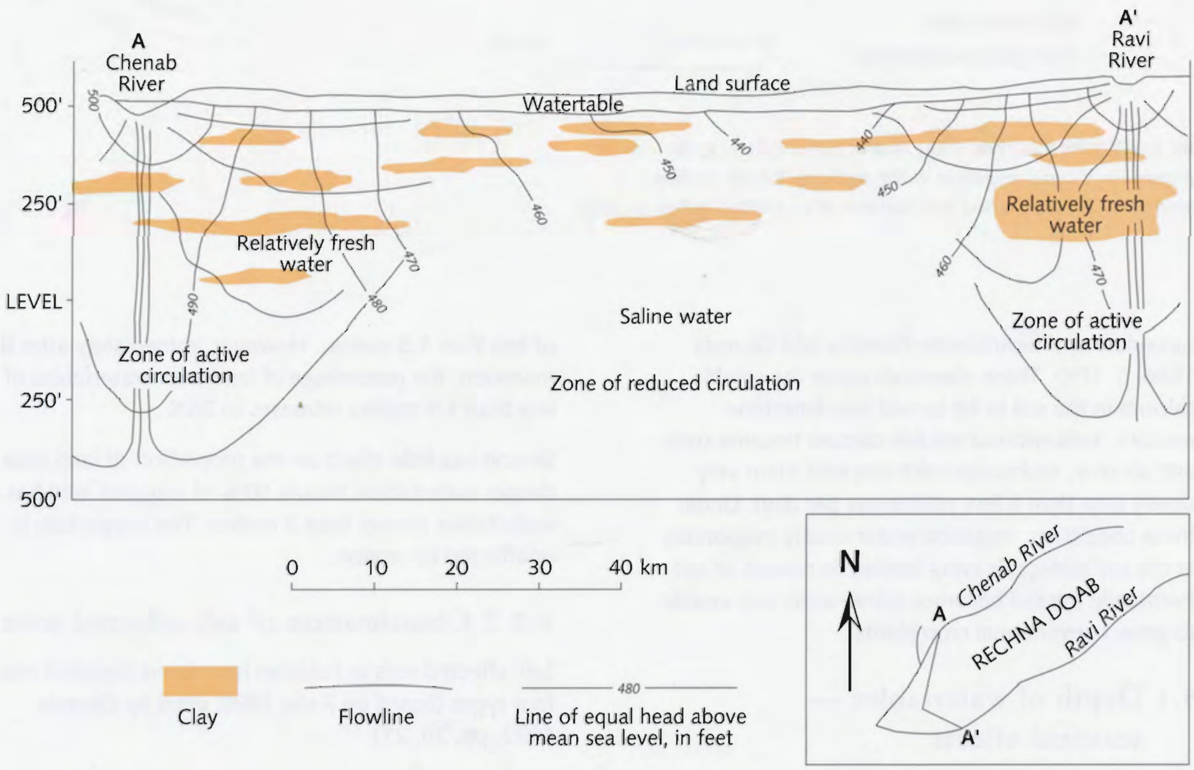

Figure 1.5. *The relationship between groundwater salinity and proximity to rivers — cross-sectional view (Swarzenski 1968). The groundwater is freshest in the zones of active circulation close to the rivers. It is most saline in the zone of reduced circulation in the centre of the doab.*

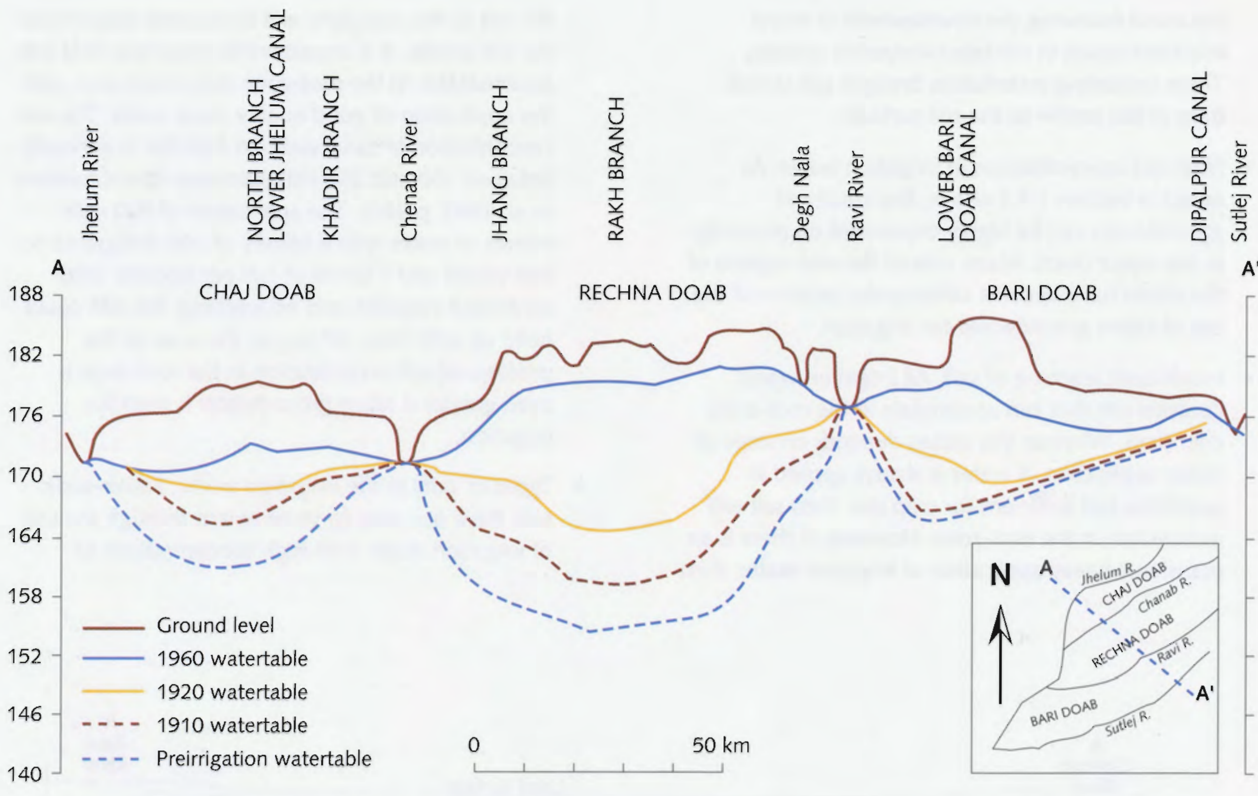

Figure 1.6. *Watertable rises in the Upper Indus following the development of canal irrigation in the mid-nineteenth century (Greenman et al. 1967, cited in Ghassemi et al. 1995, Fig 8-4, p. 381).*

carbonate and bicarbonate (Sandhu and Qureshi 1986, p. 108). These chemicals cause the soluble calcium in the soil to be turned into limestone nodules. Soils without soluble calcium become sodic and alkaline, and water infiltrates into them very slowly (less than a few millimetres per day). Under these conditions, irrigation water mostly evaporates at the soil surface, leaving behind its residue of salt. Eventually the soil becomes saline–sodic and unable to grow conventional crop plants.

1.5.1 Depth of watertables — seasonal effects

In general, watertables in Pakistan are deepest at the end of the dry season and shallowest immediately after the wet season (see Fig. 1.7). By the end of the dry season only about 13% of irrigated land has watertables of less than 1.5 metres. However, immediately after the monsoon, the percentage of land with watertables of less than 1.5 metres increases to 26%.

Season has little effect on the proportion of land with deeper watertables. Nearly 50% of irrigated land has watertables deeper than 3 metres. This proportion is unaffected by season.

1.5.2 Classification of salt-affected soils

Salt-affected soils in Pakistan have been classified into four types (based on Rafiq 1990, cited by Qureshi 1993, pp. 25, 27).

- *Slightly saline–sodic or saline–gypsiferous soils* (0.7 million hectares). These soils have slight salinity–sodicity problems, occurring as patches (about 20% of the area) in cultivated fields. About 3.5 million hectares of agricultural land is affected by this problem.

- *Porous saline–sodic or saline–gypsiferous soils* (1.9 million hectares). These soils are affected by salinity–sodicity or are saline–gypsiferous throughout the root-zone but are porous and pervious to water. They are loamy to clayey in texture. Having good physical qualities, these soils respond well to reclamation efforts (wheat/rice rotations, use of kallar grass, addition of gypsum on sodic soils).
- *Severely saline–sodic and saline–gypsiferous soils* (1.1 million hectares). These soils are severely saline–sodic or saline–gypsiferous. Some also have high watertables (within 1.5 metres). The soils are loamy to clayey in texture, dense and nearly impervious to water.
- *Soils with sodic tubewell water* (2.3 million hectares). As noted above, irrigation of land with tubewell water with high concentrations of carbonate or bicarbonate (sodicity hazard) can create sodic soils. About 70% of tubewells in the Indus Plain pump sodic water.

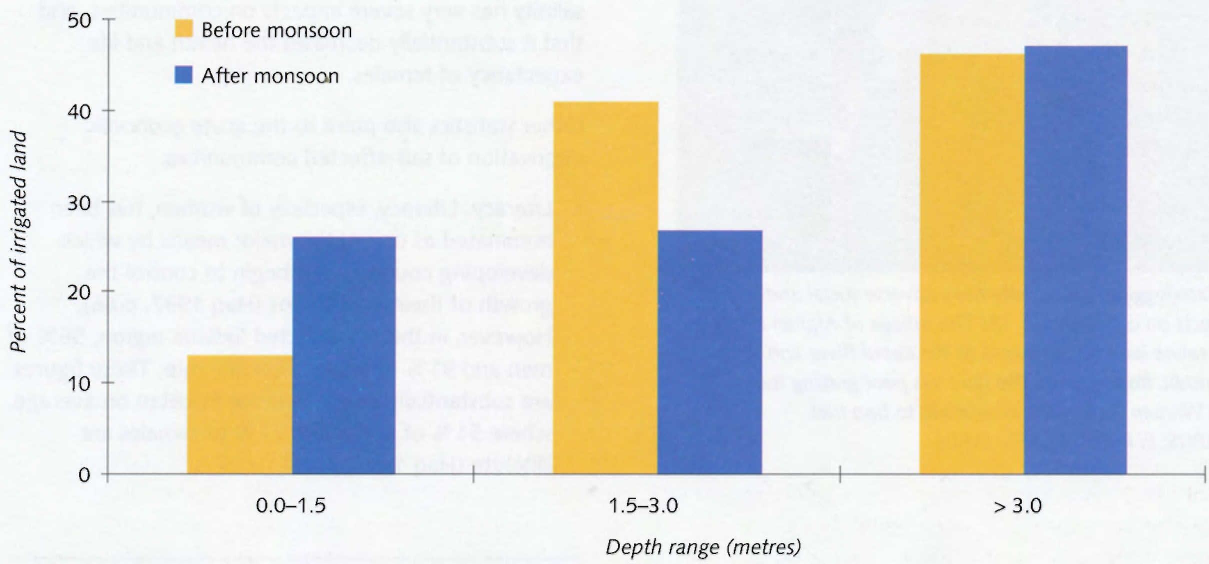

Figure 1.7. *Seasonal effects on watertable depth (Ghassemi et al. 1995, Tables 8-6 and 8-7, p. 383).*

1.6 The Impact of Salinity on the Community

Waterlogging and salinity have very adverse social and economic effects on communities in Pakistan, causing poor living standards in affected areas, health problems for humans and animals, the crumbling of mud and brick houses and difficulties in transport (Photo 1.3). Many people are forced to migrate to other areas (Sandhu and Qureshi 1986).

One marker of levels of poverty is the ratio of females to males in the community. In general, we expect roughly similar numbers of females and males in populations. However, in many South Asian countries, as communities come under increasing economic stress, the proportion of females to males in the population declines (Haq 1997, pp. 20–24).

Figure 1.8 compares the relative numbers of females and males at the whole-country and village levels. At the whole-country level (Fig. 1.8A), the United States has about 105 females per 100 males. In contrast, Pakistan is more economically stressed and has only about 94 females per 100 males.

Photo 1.3. *Waterlogging and salinity have adverse social and economic effects on communities. (A) This village of Afghan refugees is located on saline land on the banks of the Kabul River and is subject to periodic flooding. (B) The land has poor grazing for livestock. (C) Women walk many kilometres to find fuel. [PHOTOGRAPHS: E. BARRETT-LENNARD]*

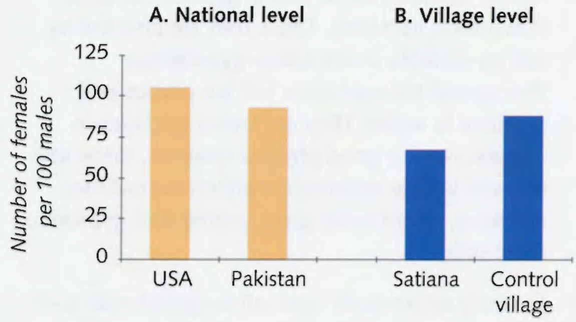

Figure 1.8. *Comparison of relative numbers of females and males. (A) at the national level (US figures calculated from United Nations 1993, p. 221; Pakistan figures calculated from Haq 1997, p. 146). (B) At the village level for a salt-affected community (Satiana region) and a non-salt-affected community (control village). (calculated from Ijaz and Davidson 1997, Table 3.7, p. 15).*

At the village level (Fig. 1.8B) the relative numbers of females and males for eight villages in a highly salt-affected region near Satiana are compared with two villages from an adjacent area with a low incidence of salinity (control group).[11] In the control group there were 88 females per 100 males, but in the highly salt-affected Satiana region there were only 68 females per 100 males.

The picture that emerges from these statistics is that salinity has very severe impacts on communities, and that it substantially decreases the health and life expectancy of females.

Other statistics also point to the acute economic deprivation of salt-affected communities.

- *Literacy*. Literacy, especially of women, has been nominated as one of the major means by which developing countries will begin to control the growth of their populations (Haq 1997, p.66). However, in the salt-affected Satiana region, 56% of men and 91% of women are illiterate. These figures are substantially worse than for Pakistan on average, where 51% of males and 77% of females are illiterate (Haq 1997, p.41).

11 The Satiana area was once regarded as one of the most productive districts of Pakistan. Salinity in the area was caused by the rising of watertables following the opening of the Lower Gugera Branch and Burala Branch canals in 1892. At present, about 22% of land is affected by salinity, 9.7% is 'totally affected' and 12.2% is 'partially affected' (Ijaz and Davidson 1997).

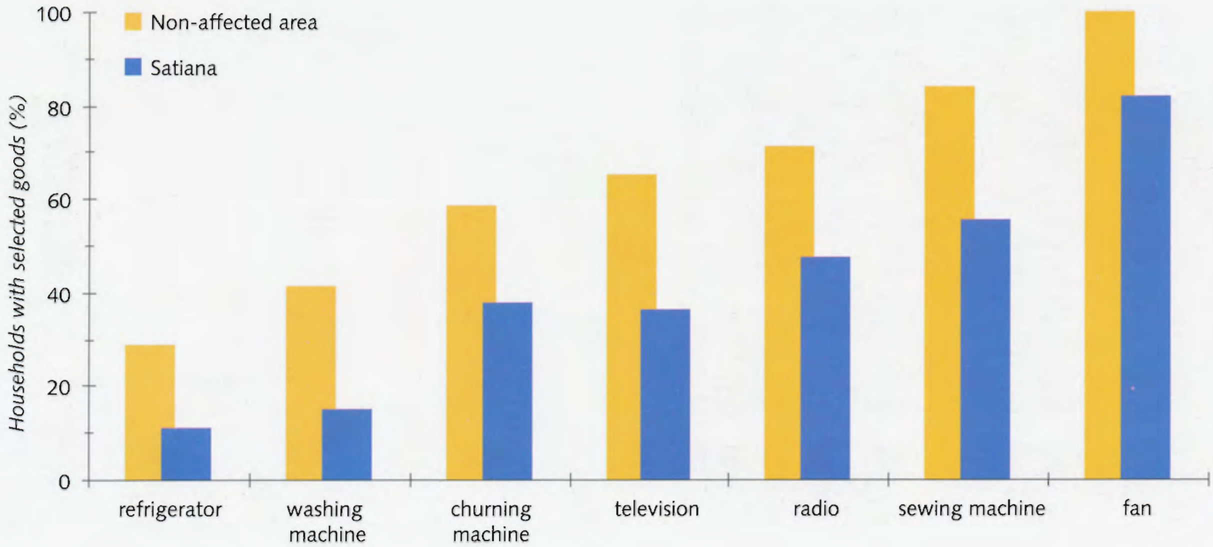

Figure 1.9. *Ownership of household goods in the highly salt-affected Satiana area and an adjacent non-affected region (Ijaz and Davidson 1997, Table 3.11).*

- *Health care*. People in salt-affected areas have poor access to basic health care facilities; in the salt-affected Satiana area only one out of eight villages surveyed has a health clinic.
- *Typical household goods*. With their reduced purchasing power, people from highly salt-affected regions have substantially poorer access to basic household equipment. Figure 1.9 compares the ownership of goods by households in the highly salt-affected Satiana area and in a nearby non-affected region. Each of the items listed would be useful to a family, be it for better health (refrigerator, washing machine, fan), income generation (churning machine, sewing machine), or information/education (television, radio). However, for each item, ownership is substantially lower in the salt-affected area.

Until very recently there has been little detailed information on the effects of salinity on communities in Pakistan. However, a picture is now emerging which suggests that communities affected by salinity are acutely economically deprived. We believe that salinity in Pakistan is a human rights issue: it is essential that income-generating agricultural systems are adopted in severely salt-affected areas.