CHAPTER 3
MAIN ENVIRONMENTAL PROBLEMS

Several key environmental problems face Tajikistan. They include water and land resources degradation, threats to flora and fauna, and to a lesser degree, contamination from municipalities and industry (including mining). The impacts that each major sector of the economy has on the environment are also summarized in this chapter. Before delving into the main environmental problems related to water, one of the most critical resources, it is important to have an overall picture of water resources and water use.

NATURAL RESOURCES DEGRADATION

Water-Related Degradation

Background on Water Resources

Basins. An organizing principle used in this Environmental Profile for discussing water resources is by drainage basin.[18] Table 3.1 presents some of the largest basins that are, in whole or in part, found in Tajikistan. The three major basins are the Amudarya, in the eastern and southern parts of the country, the Zeravshan, which cuts east to west about two-thirds of the way up the country, and the Syrdarya, which drains most of Leninabad. The Amudarya is the largest of the three basins, draining 75 percent of the country. The Pyanj,[19] Vaksh, and Kafernigan are important sub-basins of the Amudarya basin. Figure 3.1 illustrates major rivers.

Table 3.1: Major River Basins

Basin	River	Outlet	Length (km)	Area of Basin (km^2)
Amudarya	Pyanj	Amudarya	921	114,000
	Kafernigan	Amudarya	387	11,600
	Vaksh	Amudarya	524	39,100
	Bartang	Pyanj	528	24,700
Zeravshan	Zeravshan	No longer reaches Amudarya	not available	not available
Syrdarya	Syrdarya	Aral Sea	2,212 (185 in Tajikistan)	444,000

Source: Ministry of Environment.

Tajikistan is one of the few countries where internal political boundaries (*oblast*- or *raion*-level boundaries) correspond closely with watershed boundaries. Northern Leninabad is included in the Syrdarya basin. The Zeravshan basin, a very well-defined valley, runs due east-west in the southern part of Leninabad *oblast*. Its northern boundary is defined by boundaries of two *raions* and its southern, by the *oblast*. The basins of the Vaksh and Kafernigan rivers are also fairly linear, mirroring the rivers' diagonal flow through Regions under Republic Subordination (RRS), and then demarcated on a north-south basis by *raion* boundaries in Khatlon *oblast*. Virtually all of Gorno-Badakhshan Autonomous Oblast (GBAO) drains into the Pyanj basin. The remarkable correlation between political and

[18] The terms "watershed" and "basin" are used interchangeably, both meaning "drainage basin."
[19] Major tributaries of the Pyanj in Gorno-Badakhshan include the Bartang and Vanch.

watershed boundaries would greatly facilitate the adoption and implementation of a watershed-based approach to environmental management.

Appendix 2 describes the characteristics of the Syrdarya, Vaksh, Kafernigan, and Zeravshan basins in greater detail. It covers the seasonal flows, water quality in terms of turbidity, and demographic characteristics of the watersheds. It also discusses the most significant point—source of pollution problems in each basin.

Rivers, Lakes, and Reservoirs. Most of the lakes in Tajikistan are at high altitudes where populations are scarce, excluding them from significant anthropogenic impacts. Nine of the 20 lakes in the table are identified as "moderately saline," while Karakul, the largest lake in Tajikistan is "very saline." Table A1.1 in Appendix 1 shows the characteristics of major lakes in Tajikistan.

Reservoirs are unevenly distributed, owing to differences in topography, hydrological resource, and demography. Reservoirs in the Syrdarya basin are shallow with large surface areas, and reservoirs in the Amudarya basin are narrow and deep, owing to the more mountainous terrain. Table 3.2 shows their distribution by basin.

Table 3.2: Reservoirs by Basin

River Basin	Number of Reservoir by Size			Total Area	Total Volume
	(10 km^2)	(10 km^2)	Total	(km^2)	(km^3)
Syrdarya	2	2	4	571.71	4.5730
Vaksh (Amudarya)	2	1	3	111.54	10.7195
Pyanj (Amudarya)	2	0	2	5.15	0.0517
Total in Republic	6	3	9	690.40	15.3412

While reservoirs are generally associated with hydropower, they serve other uses, including irrigation, water supply, flood control, and recreation, as Table A1.2 in Appendix 1 shows. According to the data given by MOE, the designated useable volume of the reservoirs varies, but the average is roughly 60 percent of the actual volume. The presence of reservoirs can negatively harm surrounding populations. For example, the water table around Nurek reservoir has risen, causing damage to homes and settlements in the area.

Water Use

Table A1.3 in Appendix 1 shows surface water consumption by sector, comparing 1990 with 1996. In all but the industrial sector, which rose 55 percent, consumption was down. Urban water supply and irrigation consumption fell by 11 percent and 8 percent, respectively. Rural water supply and fisheries consumption manifested the biggest decrease of 41 percent each. The cumulative effect of these sectoral changes was an overall decrease in consumption of 9 percent. Agriculture accounts for 90 percent of water consumption.

Insert: Selected Tajik Rivers and Cities

Groundwater and Groundwater Use

Significant groundwater reserves are found in all of the major river basins in Tajikistan. The total groundwater reserve, excluding those in the GBAO, is 123,201 km^3. Planners (hydrologists) at the Hydromet Agency have determined that the total amount that can be withdrawn annually without negatively impacting the hydrological cycle is 6,972 km^3 (19,101.256 thousand m^3/day). The total amount withdrawn is 2,372 km^3 (6471.7 thousand m^3/day)—roughly one-third has been determined safely withdrawn. Table 3.3 summarizes the uses for groundwater across Tajikistan.

Table 3.3: Summary of Uses for Groundwater

Purpose	Annual Withdrawal (km^3)	Daily Withdrawal (m^3)
Urban drinking water	0.835	2,160.2
Industry	0.170	519.4
Irrigation	0.935	2,584.5
Rural drinking water	0.330	961.3
Discarded	0.075	232.3

Table A1.4 in Appendix 1 shows groundwater use by *raions* within the basins. Not surprisingly, the greatest amounts withdrawn for drinking water are in the largest cities, Dushanbe and Khujand. The northern *raions* of Matcha, Khujand, Asht, and Zafarabad rely heavily on groundwater for irrigation purposes, withdrawing between 216 and 520 m^3/day. Only Voce in the far south withdraws a comparable amount for irrigation at 220 m^3/day. Two of the most significant problems related to groundwater use (regardless of the purpose) are maintaining the pumps and, increasingly, paying for the electricity to run them.

Main Environmental Problems

Limited access to safe drinking water and sewage systems. Comprehensive and reliable data about the number of people with access to safe water and sewage systems (or other safe wastewater disposal) are not available. People obtain water from a variety of sources: central supply, rivers, canals, wells, hand-dug wells, and irrigation canals. Generally, open water sources that run through populated areas are the most contaminated supplies in terms of bacteriological and chemical pollutants. In 1997, 62.8 percent of the population received centrally piped water, while the remainder used water from rivers, canals, wells, irrigation ditches, and trucked-in supplies. Damage caused during the civil war, lack of maintenance due to civil strife, and lack of financing have increased the number of people using contaminated, open sources of water.

There are 669 water supplies under the control and management of the Government, including 80 municipal systems and 589 systems that service large complexes, state farms, or collective farms. Majority of the systems rely on groundwater—only 82 of the centralized systems—or 8 percent—use surface water. Table 3.4 summarizes the percentages of populations receiving centrally supplied water.

Water Supplies: Profiles of a Few Communities

Although in some communities over 50 percent of the population has centrally supplied water, on average only about 20 percent of the population in rural areas has access to safe drinking water—mainly because water supply facilities were destroyed during the civil war.

Tursunzade: All urban dwellers and 69 percent of the rural dwellers receive centrally supplied water in the *raion*. There are two municipal systems, two agency systems, and 19 state and collective farm systems. All of these systems use artisan wells that are 40 to 100 meters deep. The total length of the distribution system is 380 kilometers. Fifty percent of the systems lack the proper treatment equipment or chemicals and do not meet the sanitary standard. Of the remaining rural dwellers, 26 use water from the Karatag and Shirkent rivers (brought in by canals and ditches), and an estimated 5 percent use water delivered by trucks.

Penjkent: Almost 96 percent of urban dwellers and only 32 percent of rural dwellers receive centrally supplied water, for a total of 40 percent of the population in the *raion*. Many of the groundwater supplies are contaminated by hospital wastes, livestock farms, toilets, and solid waste dumps.

Sovietskii Raion: Total population receiving centrally supplied water is 23.3 percent, which includes only 6.1 percent of the rural population.

Table 3.4: Percentage of Population Receiving Centrally Supplied Water
(percent)

Location	1990	1991	1992	1993	1994	1995	1996	1997
Republic	65.0	65.0	65.0	63.0	63.4	63.4	63.4	62.8
Urban	97.0	97.0	97.0	97.0	97.0	97.0	97.0	95.8
Rural	51.2	51.2	51.2	51.2	51.2	51.2	50.5	48.3

Source: State Statistical Agency.

Table 3.4 is noteworthy for two reasons. First, it shows that, even in 1990, coverage was low—average coverage was only 65 percent and rural coverage just above 50 percent. Second, it indicates that coverage has declined only slightly (and consistently) from 1990 to 1997. These data do not reflect anecdotal reports that systems were damaged, if not destroyed, in war-torn areas, which may be attributable to lack of resources to assess current coverage.

Table A1.5 in Appendix 1 profiles water treatment plants for cities, settlements, and some major enterprises. Typically, actual capacity is lower than design capacity, in some cases by more than half.

Health experts estimate that 37 percent of the systems does not meet sanitary standard and requirements. Reasons include the failure to protect the source of the supply (particularly for surface water supplies), lack of adequate treatment facilities, faulty distribution systems, lack of chlorine, and failed pumps for groundwater supplies. Of water tested in 1996, 15 percent failed on account of chemical contamination, 19 percent on account of general bacteriological contamination, and 6 percent specifically failed on account of *e.coli* contamination—which was sometimes in excess of 20 times the maximum permissible concentration. The inability to protect surface supplies results in contaminated water that is then difficult to treat. Tests indicate that 40 percent of surface supplies have some form of chemical contamination, and 30 percent are bacteriologically contaminated, usually with intestinal bacilli. When surface and groundwater have close hydrological links, shallow hand-dug wells are sometimes contaminated by polluted surface water.

Of the 28 percent of the population that is not served by state controlled systems, at least 35 percent gets their water for household use (including drinking water) from contaminated ditches and hand dug wells. Another 12.5 percent uses contaminated water from irrigation canals, and at least 14 percent uses contaminated water delivered by trucks. In places where centrally supplied water is too mineralized or otherwise unsatisfactory, people prefer to use water from ditches, canals, and hand-dug wells.

Outbreaks of typhoid, bacterial dysentery, and leptospirosis attest to the grossly inadequate supplies of fresh water. Not only do people directly consume contaminated water, but inadequate supplies also contribute to poor hygiene.

Places in which groundwater is used for drinking, but is not of suitable quality, are Dangara, Yavan, and Darband in Khatlon *oblast* and Kanibadam, Isfara, and Zafarabad *raions* in Leninabad *oblast*.

Currently, no data are available about the percentage of the population that has access to sewage treatment. *Regarding data on total wastewater generated and wastewater treatment facilities, see Wastewater Treatment, page 39.*

Water-Related Calamities

Tajikistan has a naturally high proclivity for water-related disasters, due to its geography. Young, dynamic mountains characterize 93 percent of the country. Steep slopes and unstable soils contribute to the 50,000 landslides that occur annually, some of them with tragic human and economic consequences. Floods occur during periods of heavy precipitation and during the spring melt, when steep, narrow riverbeds are unable to handle tremendous surges of water. At high altitudes, vegetation, which plays an important role in stabilizing slopes, is sparse and fragile. Regeneration of vegetative matter is slow. Moreover, Tajikistan is seismically active and more than 5,000 tremors are recorded annually. The last major earthquake was in 1985 in the northern part of the country.

These fragile and unstable conditions make the lands in Tajikistan all the more susceptible to damage caused by human activity. According to environmental authorities, deforestation, cultivating and over-grazing of slopes, strip mining, and road-building exacerbate the instability of mountainous areas. Development in flood areas further contributes to loss of life and property damage. In 1998, official statistics show that 354 people died in natural disasters. During the past five years, overall damage is estimated at 404.5 billion rubles, or roughly US$7.2 million.

The regions most prone to landslides, mudslides, and floods are the slopes and valleys of the Gissar, Karategin, Vaksh, Darvaz, Vanch, Yagulem, and Piotr Pervoi ranges, as well as the Murgab basin near Sarez Lake. According to officials at MOE, anthropogenic impacts are most noteworthy in the Gissar-Zeravshan zone, where grazing, agriculture, and industry (particularly mining) take their toll on fragile slopes. The zone between the Surkhob and

Obikhingau rivers is where mudslides occur most frequently. The entire area of GBAO experiences floods and mudslides in late spring and early summer when winter snows melt. The spring and summer of 1999 have seen major disasters off the Kurmanin range in the Asht *raion* in Leninabad. A flood and mudslide in May destroyed 95 homes and, in July, a landslide killed 18 people and left 50 others missing. The consistency of sludge filled the valley in less than an hour, damaging and destroying homes, bridges, and power lines.

Table 3.5 is by no means an exhaustive list of natural disasters, but illustrates the scope and range of their occurrence.

Table 3.5: Natural Disasters

Event	Location	Date	Identified Damage
Earthquake	Khait, Garm *raion*	July 1949	18,000 people died; tens of millions of rubles property and crop damage
Earthquake	Kairakum, Leninabad *oblast*	November 1985	42 people died; 71 injured; hundreds of homes and electrical lines destroyed
Landslide	Kulyab, Khatlon *oblast*	April-May 1987	35 people died, more than 10 million rubles damage
Landslide	Navdi, Garm *raion*	1988	53 people died; 3 million rubles damage
Earthquake	Sharor, Gissar *raion*	January 1989	274 people died; 3,000 homes, 29 schools, 16 health facilities ruined; 4.5 million rubles damage
Mudslide	Shulmak, Garm *raion*	April 1992	49 people died; 2 homes damaged
Major landslide	Darband *raion*, RRS	May 1992	132 died; 25 homes destroyed
Flood	Lenin *raion* RRS	April 1993	276 million rubles damage
Major thunderstorm	Isfara, Leninabad *oblast*	May 1993	bridges and other transportation infrastructure damaged (240 million rubles)
Flash flood	Parkhar *raion*, Khatlon *oblast*	May 1993	damaged crops, destroyed the livestock of 70 families; 1.5 billion rubles damage
Flash flood	Kalaikhumb *raion*, GBAO	May 1993	18,000 rubles damage
Cloudburst	Djirgital *raion*, RRS	May 1993	10 km of road destroyed; 25.9 million rubles damage
Cloudburst	Lenin *raion,* RRS	May 1993	homes, greenhouses, buildings, and bridges destroyed; 3.6 billion rubles damage
Mudslide	Djirgital *raion*, RRS	March 1994	6 people died, 4 homes destroyed, 70 sheeps and 12 cattles killed
Mudslide	Asht *raion*, Leninabad	April 1994	destroyed settlements, 16 homes, 82 infrastructure objects including 38 bridges, 20 km of roads; damage to communication lines (40 million rubles) and a salt factory (80 million rubles)
Windstorm	Bokhtar *raion*, Khatlon	June 1994	*kolkhoz* and *sovkhoz* administrative buildings destroyed; severe crop damage

Event	Location	Date	Identified Damage
Landslides and mudslides	Shulmak, Garm *raion*, RRS	May 1994	4 people died, homes destroyed
Flood	Khatlon	March 1998	Yahsu River dam collapsed, damaging 1,500 homes, 2 schools, 14 administrative buildings, 1 hospital, 3 km electrical lines, 26 km roads, 8 bridges and 1,748 ha of wheat; 1,500 families lost shelter and assets
Landslide	Garm *raion*, RRS	April 1998	damage 10 million rubles; 127 homes, a school, 12 flourmills, electricity lines and water pipes
Landslide	Darband *raion*, RRS	April 1998	destroyed 76 houses; 125 families lost shelter and livelihoods
Mudslide and flood	Kulyab, Khatlon *oblast*	April and May 1998	Homes, bridges, crops destroyed; damage 22.7 billion rubles
Mudslide and flood	Asht *raion*, Leninabad	May 1999	95 homes destroyed
Landslide	Asht *raion*, Leninabad	July 1999	18 people killed, 50 missing; destroyed 150 homes and damaged 200; ten bridges and 10 km of power lines damaged; damage estimated at 146 million rubles
Landslide	Djergatai	July 1999	5 people killed
Floods	GBAO	August 1999	250 homes and 3 electricity substations destroyed; roads near Murgab damaged

Source: Ministry of Environment.

Hail is another natural event that causes tremendous damage to property and crops. Hail damage in 1999 was estimated at US$10,000.

Lake Sarez

A beautiful alpine lake, Lake Sarez poses an environmental threat of tremendous magnitude to Central Asia. Created by an earthquake in 1911 that dislodged 2 billion cubic meters of earth, the natural reservoir now holds 17 cubic kilometers of water, almost half the size of Lake Geneva. If the dam were to fail, it would damage a territory along the course of the Bartang, Pyanj, and Amudarya rivers of up to 52,000 km^2 and populated by 5 million people in 4 states. International experts believe the 4 kilometer-wide dam is secure, but warn of dire consequences if it is not. A more urgent concern is the threat of a large landslide into the lake, causing a tidal wave to sweep over the dam. The World Bank is trying to raise US$4 million for a project that has three main objectives:

- install an early-warning device to save lives in an emergency;
- assess the risks; and
- rank disaster mitigation options.

Soil Erosion and Salination

Land degradation from erosion and salination are noteworthy problems, considering that so little of the land is arable and mountainous regions are prone to natural disasters as discussed above. Although the picture of soil conditions is incomplete given the lack of monitoring and surveying, particularly in the past 10 years, officials register concern about land degradation and its impacts on society and the economy. Data about soil erosion and salination in agricultural areas exist, but the significant erosion that takes place in mountainous areas is not monitored. Studies carried out by the Tajik Pedagogical Institute indicate that 38 percent of the country's soils are eroded, while some in the Academy of Sciences believe that erosion affects up to 60 percent of Tajikistan's total territory. The young and dynamic nature of the mountains, which cover 93 percent of the country, accounts for a high degree of natural erosion. These same characteristics make them fragile and easily affected by human activities, which only exacerbate the rate and scope of erosion. MOE cites over-grazing, deforestation, small-scale agriculture, mining and road building as factors which significantly exacerbate erosion in mountainous areas, even where permanent human settlements are scarce.

Yavan Valley

Yavan Valley in Khatlon is known for its extremely degraded landscapes, where ravines of 100 meters (m) wide and 25 m deep characterize 6,000 ha or 20 percent of the terrain. The area was developed for irrigation in the mid-1960s and almost immediately began to show the ill-effects of improperly managed irrigation. Water was applied in excess, but the greatest damage came from the failure to manage drainage water. Appropriate drainage infrastructure was not constructed, and other erosion-control measures were not put in place. Improper disposal of drainage water has increased the flow in the Yavan River (10 times the former flow in the winter and 200 times the former flow in summer) and has raised groundwater levels. Both phenomena contribute to erosion. The costs for restoring this territory are prohibitive.

The Scientific Research Institute under the Ministry of Agriculture (MOA) suggests that 60 percent of irrigated territory in 1996 suffered from water erosion. From 1962 to 1977, erosion-control measures were practiced on irrigated lands. After 1977, however, funds were not budgeted for such measures. Estimates in 1992 indicate that 27.2 thousand ha of irrigated land were severely eroded. The worst cases of erosion are found in Yavan and Bokhtar *raions*. In Asht and Shaartuz *raions* (in the far north and far south of Tajikistan, respectively), wind erosion strips the thin and fragile topsoil.

Salination represents another significant form of degradation. As a result of natural conditions and improper irrigation and drainage practices, soils are salinized in many agricultural areas.[20] About 4,000-5,000 ha are taken out of use per year because of salination and waterlogging.[21]

[20] Salination is not a new problem in Tajikistan. In the 1930s, soils in some areas of the Vaksh Valley were highly salinized, inflicting heavy losses on agriculture. Construction of drainage infrastructure lowered the salinity levels considerably.

[21] A small percentage of land is taken out of cultivation each year for lack of water altogether where irrigation and pumping systems have failed.

By 1996, 110,000 ha were identified as experiencing differing levels of soil salination. Slightly more than 34,000 ha (31 percent) are newly irrigated lands (opened in the 1960s and 1970s), located in Asht, Tashgabad, and Dangara. The remaining 75,589 ha are older irrigated territories experiencing secondary salination. They are found mainly in the Vaksh Valley in Khatlon *oblast* and Khujand and Kanibadam *raions* in Leninabad *oblast*.

Table 3.6 identifies the extent of salination by *oblast*. Roughly 1 percent and 3.7 percent of the total irrigated territory are highly salinized and moderately salinized, respectively. The newly irrigated lands in Leninabad *oblast* experience higher salinity levels, in general. Almost 2.5 percent of the irrigated lands in Leninabad *oblast* are highly salinized, while 5.3 percent are moderately salinized.

Table 3.6: Salinized Lands by Oblast, 1996
(hectares)

Region	**Salination Level**			
	None	**Slightly**	**Moderately**	**Highly**
Leninabad	197,270	46,682	10,589	4,776
RRS	99,906	130	28	25
Khatlon	274,136	28,777	15,724	2,812
—Kulyab	76,486	2,273	779	192
—Kurgan Tyube	197,650	26,504	14,945	2,620
GBAO	22,137	0	0	8
Tajikistan	593,449	75,589	26,341	7,613

The main reasons for increase in salination are the following:

- failure to construct adequate drainage infrastructure, particularly in areas characterized by naturally occurring high levels of soil salinity (newly irrigated regions); and
- poor maintenance of irrigation and drainage infrastructure, particularly in the last 10 years.

Quality of Irrigated Lands, page 52, discusses other related forms of land degradation caused by agriculture.

Threats to Flora and Fauna

Tajikistan has unique and fragile ecosystems, that are rich in biodiversity. Because of lack of funding and capacity, little is currently known about the conditions of important resources such as forests and other flora, fauna, and biodiversity, in general. The following subsections describe conditions to the degree that they are known.

Deforestation

It is believed that, in the last 120 to 170 years, Tajikistan has lost 75 percent of its historical forest cover. The loss of tugai forests—vegetation found in desert riparian zones—is one of the most significant losses. Tugai cover comprises only 0.6 percent of total forest cover now, but was believed to have constituted almost 5 percent of total forest cover in the last century. It is estimated that forest resources are used or degraded at 1.8 to 2.4 times the rate of natural regeneration and reforestation efforts. In mountainous areas in particular, where conditions are harsh, regeneration rates are low. Evergreens there grow one meter every 20 years, so it takes 130 to 150 years for an evergreen to reach full height.

The primary reason for unauthorized forest cutting in the past nine years has been for use as fuelwood as provisions of coal, gas, or LPG—previously supplied by the Government—have been drastically reduced. Tugai forests, which are usually found in river valleys, have been reduced by three phenomena: encroachment by humans, lowered water table from excessive withdrawals for irrigation, and fires. Tajikles has not been able to buy pesticides in recent years, which has resulted in a higher incidence of disease. Many native pistachio stands were converted into vineyards because they tend to occupy the microclimatic zones that suit grape cultivation. Today, pistachio stands experience pressure from livestock and fires.

Commercial forestry was never significant, and the degree to which it is practiced today is unclear. During the Soviet era, Tajikistan imported 100,000 m^3 annually to cover its needs. Currently, very little wood is imported.

The Cabinet of Ministers issued a special resolution in 1994 on "The creation of pine and poplar forests, plantations of nut trees, and production of seedlings," that required greater production of Tajikles but with little funding made available. Nonetheless, in 1997, 2000 seedlings were given away for planting on farms and in settlements. Two thousand additional ha were planted with seeds. Unfortunately, no monitoring is done, so survival rates are not known.

Tajikles has an official workforce of 10,000. However, workers in the forestry sector have historically experienced the lowest average monthly wages, even lower than workers in the agriculture and health care sectors, as Table 3.7 shows. In 1996, forestry sector workers were making an average of 11 percent of workers in the industrial sector.

Table 3.7: Selected Average Monthly Wages

Sector	1985	1990	1993	1996
Industry	175	231	26,906	8,080
Agriculture	135	177	11,097	1,702
Health care	131	167	10,384	1,124
Forestry	120	164	10,721	889

Source: IMF (Russian rubles through 1995, Tajik rubles thereafter).

Given the poor wages, it is unlikely that a high percentage of Tajikles employees are at their posts.

Desertification

In the early 1990s, the Scientific Research Soil Institute under the MOA estimated that 2,200 ha were desertified. This figure likely addresses agricultural lands only. Awareness of the phenomenon is relatively new, and lands were not historically monitored for such conditions. Specific data about desertification are not available. Experts now recognize that overgrazing, salination, and erosion contribute to desertification. Figure 3.2 (Degraded Lands) identifies areas where desertification may be a problem.

Awareness about the threat of desertification prompted the Government of Tajikistan, and specifically, MOE to embark on a program to prepare a National Action Plan to Combat Desertification. One of the primary objectives of the plan will be to develop a program to understand and quantify the extent of desertification (and potential desertification) in the country. Secondly, the plan will identify remediation and preventative actions that can be taken to counter and halt desertification.

Biodiversity Loss

Tajikistan first made provisions to identify and protect endangered and threatened species in 1979, when it published the first Red Book.[22] The second and most recent publication of 1988 identifies a total of 388 plant and animal species as endangered. The breakdown of the species follows:

Table 3.8: Endangered Species[a]

Plants		**Animals**	
Fungi	4	insects	50
Bryophytes	8	molluscs	8
Pteridophytes	6	fish	4
Gymnosperms	1	reptiles	21
Angiosperms	207	birds	37
		mammals	42
Total	**226**	**Total**	**162**

[a] Academy of Sciences of the Tajik Soviet Socialist Republic. *Red Book of the Tajik Soviet Socialist Republic*. Dushanbe, 1988.

Not surprisingly, majority of the listed species reside in the western part of the country, where concentrations of people and economic activities are much greater than in the east.

No complete surveys of fauna and flora have been carried out within the last 10 years. During the past 70 years, populations and economic activities expanded in scope and intensity, irrevocably altering habitats. Agriculture, for example, converted vast territories of wild lands. The use of agrochemicals may have more directly harmed wildlife in some cases. Some experts feel that the population movements during the civil upheaval of the early 1990s disrupted habitats that had been previously relatively untouched. There are claims that armed fighters hunted wildlife (protected and unprotected) for food and sport, which impact populations in war-torn areas. Fires, too, have taken their toll on habitat.

Tajikistan has a system of parks and protected areas based on the protection categories of the Soviet system. In addition to the areas shown in Table A1.6 in Appendix 1 there are 24 hunting and fishing farms.

Tajikistan lacks a comprehensive plan for the protected areas system, and for the protected areas themselves. Tajikles, the state forestry agency, is technically in charge of the protected areas, but severe budgetary constraints, including lack of resources to access the areas, prevent protection activities from being carried out. Currently, academics at Academy of Sciences and other institutions of higher learning occasionally prepare plans and proposals for the protected areas that match their research interests, but they tend to be

[22] Red Books were prepared in all of the Soviet republics to identify and describe endangered and threatened flora and fauna. They had a similar format, but the frequency of publication varied among republics.

narrow in focus and rarely funded. Some NGOs have taken an active role in lobbying for the protected areas and procuring assistance for people who live in and near the parks. For example, the NGO Khukhiston was successful in persuading the President's Office to contribute emergency funds for the reconstruction of some of the on-site facilities to commemorate the 60th anniversary of the establishment of Tigrovaya Balka reserve. The Youth Ecological Center has disbursed small grants to residents near Kusavlisaisky Nature Reserve to start small workshops to generate income and reduce the need to utilize resources from the refuge.

Insert: Degraded Land in Tajikistan

MOE would promote tourism at national parks and build a service industry to employ residents in and around the parks, thereby reducing the need to exploit resources within those parks. Currently, the parks are difficult to access, and lack tourist infrastructure.

Tigrovaya Balka[a]

Established in 1938, Tigrovaya Balka is Tajikistan's oldest nature reserve. It was established primarily to protect 25,000 ha of rare tugai from the rapid development of agricultural lands for cotton that was prevalent in the early 1930s. Tugai forest is an ecosystem of plants and trees found in riparian zones of the deserts of Central Asia comprised of turanga and jiddah, the grbenschuk bush, wild sugar cane, and reeds. At least 30 rare animal species inhabited the forest, which was named after the Turan tigers that occupied the territory until 1957.

The civil war took a heavy toll on the reserve. Roughly 20,000 refugees lived in the reserve in 1992 and 1993, and even by 1998, military posts established in the reserve during the war had not yet been removed despite a presidential decree issued on 14 August 1998. Both the refugees and the military presence have degraded the natural habitat.

The Government, in recognition of the value of the reserve, has pledged substantial funding. In 1998, the Ministry of Finance allocated 10 million rubles (US$12.8 thousand) to Tajikles for rehabilitation works in preparation of the 60th anniversary of the reserve and a government decree mandates that 30 million rubles (US$28.2 thousand) would be allocated in 1999 and subsequent years for further rehabilitation. The amounts actually disbursed are unconfirmed.

[a] Shaposhnik, Rozaliya. "Tigrovaya Balka—A Unique Part of Nature of Tajikistan and of Entire World." *Tajikistan Economic Review*, Issue 20 (58), October, 1998.

URBAN AND INDUSTRIAL POLLUTION

Background

Although Tajikistan has more of an agriculture-based economy than an industrialized one, there are, nonetheless, several large industrial complexes and population centers that produce concentrations of pollutants and wastes. The population is two-thirds rural, but by 2025, is expected to be divided evenly between rural and urban dwellers.

Table 3.9: Rural and Urban Populations
(percent)

	1990	1995	2025
Urban	32.2	32.2	49.9
Rural	67.8	67.8	50.1

Source: World Health Organization.

Populations for the largest cities are listed in Table 3.10. Their location within the country and densities (if available) are also given.

Table 3.10: Populations and Densities of Largest Cities

City	Location	Population (thousands) 1993	Population (thousands) 1996	Population Density: people per km^2 (1996)
Dushanbe	RRS	540.1	515.1	4,010
Khujand	Leninabad	162.4	156.4	713
Kulyab	Khatlon	83.1	83.8	513
Kurgan Tyube	Khatlon	58.7	57.0	57.0
Ura Tyube	Khatlon	49.5	52.6	na
Tursunzade	RRS	40.4	38.0	na
Khorog	GBAO	21.7	24.4	na

Source: State Statistical Agency.

The country has experienced tremendous population movements because of the civil war and economic crisis. At least 50,000 people died during the civil conflict (most in 1992 and 1993). People with means emigrated, and many others fled as refugees during times of heavy fighting. Many refugees were repatriated in 1995, and a second large repatriation effort is currently ongoing. At times, Tajikistan has absorbed refugees from other countries as well. Despite the dramatic population movements, rural to urban migration is not as pronounced in Tajikistan as in many other developing countries.

The main environmental problems in urban areas are uncontrolled dumps of solid waste, lack of sewage systems, and lack of safe drinking water. In larger cities, emissions from automobiles are a growing problem now that the economy is showing signs of recovery. Automobiles that were not used in the early 1990s for lack of fuel, spare parts, and security are now being driven again. Cities are also industrial centers, and as the following tables show, many industrial complexes produce polluting emissions.

Table 3.11: Industrial Output, Employment, and Productivity, 1991-1996

	1991	1992	1993	1994	1995	1996
Output	100.0	73.2	64.4	44.4	38.3	29.2
Employment	100.0	97.4	83.1	80.1	71.4	70.6
Productivity	100.0	75.1	77.5	55.4	53.7	41.3

Source: State Statistical Agency.

Table 3.11 shows employment and productivity decreased between 1991 and 1996, productivity at an even more dramatic rate than employment.

Table 3.12 shows the industrial structure in more detail. Contractions were most pronounced in the fuel, chemicals, mechanical engineering and metalworking, and construction materials subsectors. Production in the electric energy production and nonferrous metallurgy subsectors decreased more slowly, resulting in an increase in their respective shares of overall output.

Table 3.12: Industrial Structure

	Number of Enterprises, 1996	Number of Employees ('000) 1996	Employees per Enterprise	Output (% of Total)	
				1991	1996
All industry	1,308	115.3	89	100.0	100.0
Electric energy	15	6.7	447	3.0	16.7
Fuel	6	1.6	267	1.8	0.4
Nonferrous metallurgy	9	16.8	1,867	21.6	35.2
Chemicals	9	5.4	600	9.3	4.1
Mechanical engineering and metalworking	548	21.6	39	6.1	2.9
Paper	29	1.2	41	1.8	0.1
Glass	4	1.8	450	1.0	0.4
Construction materials	91	6.1	67	8.3	1.2
Light industry	89	34.7	390	22.4	16.3
Food (including flour milling)	470	17.7	38	24.6	20.9

Source: State Statistical Agency.

In terms of number of enterprises, mechanical engineering and metalworking and the food industry dominate with 548 and 470 enterprises, respectively. Many of the metalworking enterprises employ galvanizing processes that produce effluents high in heavy metals, and emissions that contain volatile organic compounds (VOCs) and toxic organics.

Air Pollution

Air pollution levels roughly mirror economic performance in the 1990s. Table 3.13 shows that countrywide levels of pollution decreased through 1996 (when they were less than one-third the 1991 levels) and increased slightly in 1998. Another noteworthy aspect of Table 3.13 is that it shows the very low level of emissions treatment available. Even before the economic crisis, the highest percentage of emissions treated in Tajikistan was 21 percent. The percentage of total emissions treated decreased to 6 percent by 1996. Data for 1997 and 1998 were not available.

Table A1.7 in Appendix 1 (Pollutants by City and Year) shows how air pollution profiles differ according to city. Fluorine and hydrogen fluoride are highly toxic pollutants emitted by the Tajik aluminum plant in Tursunzade. The table also reveals how unevenly data were collected. After 1995, there was no recorded monitoring of particulates. Disaggregated data for Kulyab were not available after 1992, and for Tursunzade, after 1991.

Stationary Source Pollution

Although industrial production has dropped considerably during the 1990s, stationary sources nonetheless account for some of Tajikistan’s air pollution. The main point-source producers are industrial (manufacturing) enterprises (64 percent), building and transport enterprises (10 percent), cotton processing (8 percent), and food processing (4 percent). Data indicate that the neutralization of harmful substances emitted by stationary sources rose in Khujand, Kurgan-Tyube, and Tursunzade between 1997 and 1998 after having declined since 1992.

Table 3.13: Air Pollution by Stationary Sources
(‘000 tons)

Pollutant	Annual Emissions								
	1990	1991	1992	1993	1994	1995	1996	1997	1998
Sulfur dioxide	16.50	17.00	12.00	8.30	4.20	2.80	1.90	N/D	N/D
Carbon monoxide	50.10	42.90	41.30	33.80	28.50	27.80	22.50	N/D	N/D
Fluorides	0.20	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Chlorine	0.05	0.04	0.04	0.04	N/D	N/D	N/D	N/D	N/D
Ammonium	1.10	0.04	0.40	0.30	N/D	N/D	N/D	N/D	N/D
Particulates	35.0	28.70	19.20	15.30	N/D	N/D	N/D	N/D	N/D
Carbon dioxide	2.20	1.70	0.90	0.70	0.30	0.60	0.20	N/D	N/D
Total	115.40	100.50	80.80	63.90	69.90	43.80	30.40	31.80	33.00

Source: Ministry of Environment.

Table 3.14 shows the breakdown of total monitored pollutants.

Table 3.14: Pollutants Emitted by Year and Location
(thousands)

	1991		1992		1993		1994		1995		1996		1997	1998
	tons	% treated	tons	% treated	tons	% treated	tons	% treated	tons	% treated	tons	% treated	tons	tons
Tajikistan	100.5	21	81.7	17	63.90	15	70.0	45.0	43.8	13.0	30.1	6.0	31.8	33.0
Dushanbe	20.5	25	11.6	23	7.30	18	30.2	91.0	3.3	15.0	1.8	23.0	1.6	1.4
Leninabad *Oblast*	22.7	18	18.6	17	13.10	16	7.9	8.0	5.3	15.0	3.3	9.0	4.8	4.9
Khujand	9.1	14	6.8	10	3.80	8	3.2	13.0	1.4	29.0	0.5	20.0	0.3	n/d
Khatlon *Oblast*	16.4	30	11.3	45	10.50	21	1.7	47.0	5.6	5.0	0.5	40.0	n/d	n/d
Kurgan-Tyube	10.3	17	5.3	19	4.90	8	0.4	25.0	0.3	34.0	0.3	0.0	0.5	0.5
Kulyab	1.1	28	1.1	18	0.72	n/d	0.1	0.0	0.1	0.0	0.1	0.0	n/d	n/d
GBAO	0.3	34	0.2	50	0.03	0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.2
Khorog	0.3	34	0.2	50	0.03	0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.2
RRS	40.6	17	40.0	11	32.90	9	30.2	7.0	29.6	7.0	24.5	7.0	23.60	24.4
Tursunzade	30.5	12	33.9	6	30.10	7	29.4	7.0	29.3	7.0	24.4	9.0	23.40	24.1

Source: State Statistics Agency.

In recent years, pollution caused by household heating impacts air quality. Gas and LPG, both clean-burning fuels widely used prior to 1991, have been difficult to procure, so households have been burning wood, dung, and other wastes for heating and cooking. Secondly, the deterioration of the waste removal system has caused people to burn dumped garbage, including piles of leaves in the cities. This practice is considered to be harmful to health because of the smoke and other potentially harmful constituents (heavy metals and organic wastes from burning plastics). Even if permanent health damage is not suffered, reports of allergic symptoms have increased. These types of activities contribute to poorer air quality.

Mobile Source Pollution

Automobile transport is a major source of air pollution, contributing up to 70 percent of the total pollutants. Exhaust can contain up to 200 components, many of which are toxic.[23] The main ingredients of exhaust are CO_2, CO, soot, lead, and carcinogenic carbon compounds. The amount and composition of exhaust depends on factors such as the technological design of the vehicle, level of maintenance of the engine, and fuel quality.

The total number of registered vehicles in Tajikistan in January 1999 was 202,253—almost 30 people per registered vehicle. Their distribution by region is illustrated in Table 3.15.

[23] The Government has been unable to control the quality of imported fuel.

Table 3.15: Vehicles by Region

Region	Number	Percent
Leninabad	91,395	45.2
Khatlon	46,606	23.0
GBAO	6,803	3.4
RRS	57,449	28.4

Source: Ministry of Environment.

Leninabad has 31 percent of the population and close to half of all of the registered vehicles, a testament to its general better economic conditions. There are 29,416 cars in Dushanbe, accounting for slightly more than half of the vehicles in RRS.

Experts estimate that 70 percent of cars and trucks are at least 10 years old and poorly maintained. They note that automobile traffic between 1992 and 1995 decreased dramatically, but the availability of fuel and greater security have led to an increase in cars on the roads. Fuel quality is not controlled and officials at MOE express concern on the impact that dirty fuel has on air quality, particularly when burned by poorly maintained engines. Emissions monitoring is carried out sporadically in the cities by the traffic police, but no data are recorded.

Some experts note concern about the pollution produced by diesel locomotives and airplanes. Pollutants from locomotives include CO_2, NO_2, various carbon compounds, sulfur dioxide, and soot. The amount of sulfur emitted is directly related to the amount of sulfur and other additives in the diesel fuel, as well as the method of combustion. A high content of harmful additives in diesel fuel is particularly polluting when engines are idling because the fuel combusts at too low a temperature, and the mixture of fuel and air is not optimal. The main offending pollutant of idle engines is NO (nitrogen oxide).

A jet plane burns 15 tons of fuel in one hour. In that time period, it consumes and processes 625 tons of air and emits 46.8 tons of carbon oxide, 18 tons of steam, 635 (kg) of carbon monoxide, 15 kg sulfur dioxide, and 2.2 kg of heavy particulates. In order to reduce the impact of such emissions, it is recommended that airplanes be towed while on the ground rather than propel themselves. The overall contribution of diesel locomotives and airplanes to air pollution is insignificant.

Water Pollution

The level of wastewater treatment in Tajikistan is low, as Table 3.16 shows. Data indicate that, for wastewater dumped to surface water bodies, the overall level of treatment decreased from 37.8 percent in 1991 to 31.7 percent in 1995. However, the amount of "polluted" water in the total amount of wastewater is relatively low. In 1991, the percentage of "polluted" water in the total amount of wastewater was 2.3 percent. In 1995, was less than

1 percent.[24]. Leninabad *oblast* and its main city, Khujand, had the highest levels of treatment in 1991 and evidenced decreases in treatment levels of around 35 percent by 1995. The two cities that had the second highest levels of treatment in 1991—Kulyab at 44.4 percent and Dushanbe at 37.8 percent—experienced increases in level of wastewater treatment, owing to the fact that the amount of wastewater and polluted wastewater decreased markedly. The distinction between total wastewater and "polluted" wastewater suggests that water consumption is characterized by a high degree of waste, and considerable dilution occurs even before treatment.

The total amount of water treated and supplied in 1998 was slightly over 1 million (m^3) per day, while the total amount of wastewater collected and treated was 167,000 m^3 per day—roughly 17 percent of the total amount supplied.

[24] Wastewater data do not include agricultural wastewater, only industrial and municipal. Disaggregated data about the amount of wastewater generated by sector were not available.

Table 3.16: Wastewater Released to Surface Water Bodies

	1991			1992			1993			1994			1995		
	Total waste water (m^3)	Total polluted waste water (m^3)	% of total waste water treated	Total waste water (m^3)	Total polluted waste water (m^3)	% of total waste water treated	Total waste water (m^3)	Total polluted waste water (m^3)	% of total waste water treated	Total waste water (m^3)	Total polluted waste water (m^3)	% of total waste water treated	Total waste water (m^3)	Total polluted waste water (m^3)	% of total waste water treated
Tajikistan	4,732	113	37.8	4,854	89	33.5	4,805	72	28.7	4,922	43	19.6	4,526	38	31.7
Dushanbe	173	52	32.5	158	37	25.5	134	27	21.0	102	0	0.3	4	0	47.8
Leninabad *Oblast*	1,306	31	48.4	1,270	24	42.9	1,396	26	43.7	1,381	24	41.7	1,392	16	31.4
Khujand	53	29	54.7	46	22	47.8	48	24	49.8	45	21	46.7	36	14	36.9
Khatlon *Oblast*	2,606	6	20.0	2,814	6	27.3	2,582	7	22.0	3,084	11	29.9	3,008	14	31.5
Kurgan Tyube	15	1	7.7	11	1	11.1	10	1	11.3	14	2	14.8	27	5	18.0
Kulyab	9	4	44.4	8	4	50.0	9	5	52.6	10	5	52.4	10	5	54.9
GBAO	57			47	0		44	0	0	49	0	0	0	0	0
Khorog	0			0	0			0	0	0	0	0	0	0	0
RRS	590	24	53.3	565	22	31.4	649	12	39.0	306	8	7.2	122	8	31.2

Source: State Statistical Agency (Note: Blank cells indicate no data available).

Wastewater Treatment

Poorly treated wastewater is one of the principal culprits of water supply contamination. As Table A1.8 in Appendix 1 shows, wastewater treatment facilities were constructed even in small settlements in the 1980s, but of the 57 identified in the table, only 12 (21 percent) are operating satisfactorily. The facilities operating satisfactorily in Vaksh, Kolhozabad, and Faizabad are small systems in relatively large settlements, indicating that coverage is probably low. Kairakum, Kanibadam, and Chkalovsk are also relatively large population centers, but their operating systems are large enough to provide adequate coverage to the population. Many of the 13 treatment facilities not operating at all are small systems in small settlements or in enterprises that were built in the late 1980s. The reasons they are not functioning may include the following: design and/or construction may have been faulty, enterprises may not be operating at full capacity, if at all, or they were damaged by the civil war. Eight of the facilities are described as "unsatisfactory," but comments such as "needs capital investment," "needs repair," "needs reconstruction," and "emergency conditions" indicate the dire conditions characterizing 25 percent of the facilities.

The principal reason for the poor conditions of sewage and water supply systems is lack of finances. Settlements do not have the means to raise their own revenues, and the central budget is too strained to provide finances. Data from 1980s indicate that the conveyance losses were 18 percent, the designated "allowable" loss according to Soviet planners. Little is known now about true conveyance losses in water supply or sewage systems, but reports of severely deteriorated and damaged distribution systems indicate that they are high.

Surface Water Pollution

Little is currently known about surface water quality because of the deterioration of the monitoring network. However, experts at MOE identified the following rivers as the most polluted:

- Syrdarya: Water is highly mineralized from agricultural return flows. Concentrations of sulfates exceeded MPCs by 4-5 times in 40 percent of the tests carried out.[25]
- Kafernigan River: Contains sewage, agricultural chemicals, and petroleum products.
- Vaksh and Pyanj: Characterized by natural mineralization and industrial contaminants; sulfates and nitrites sometimes three times higher than the maximum permissible concentrations.
- Zeravshan River: May contain mercury from gold processing plant on one of the main tributaries.

Garbage and untreated wastewater also contaminate canals and ditches, which are increasingly serving as sources for drinking water.

[25] Experts at the Ministry of Environment suggest that many of the sulfates are naturally occurring.

Groundwater Pollution

High levels of hardness, sulfates, chlorides, nitrogen compounds, heavy metals, and bacteria are found in groundwater in several places in Tajikistan. Temperature changes have been recorded in some groundwater deposits as well. Groundwater deposits have become contaminated under the impact of human economic activities, particularly the inappropriate use of fertilizers and poisonous chemicals dumped from factories and enterprises. Municipal wastewater and runoff from livestock yards also contaminate groundwater supplies.

Contamination of groundwater resources by the Vaksh Nitrogen Fertilizer plant in Kurgan Tyube, resulted in the closing of drinking water supply wells in 1979.

Mineral fertilizers used on cotton crops have contaminated groundwater used for the water supply in the Kulmunda and Bulokchinar districts of Gissar. The highest concentration of nitrates in water supplies have been identified near the canning plant and chemical factory in Isfara at concentrations from 45 milligram per liter (mg/l) to 230 mg/l. Concentrations of nitrates in groundwater in Zafarabad, Matchin, Kafarnigan, Bokhtar, Lenin, Gissar, Tursunzade *raions* exceed the maximum permissible concentration (MPC). For example in the populated areas of Gissar, Dushanbe, Kafernigan, concentrations of nitrates sometimes are twice the MPCs.

In the northwest of Tursunzade *raion* where the Tajik aluminum factory is located, fluorides contaminate groundwater resources. According to data of the factory itself and MOE, samples from the monitoring wells in 1993 and 1994 contained concentrations of fluoride exceeding the MPC by almost 20 times.

Storage areas for sludge from Yavan electrochemical factory, to the southeast of the plant, contaminate its own water supply. Table 3.17 illustrates the type and extent of contamination:

Table 3.17: Pollutants in Groundwater near the Yavan Electrochemical Factory

Pollutant	Concentrations (mg/l)	MPC	Times in Excess of MPC
Nitrates	53 – 250	45	1.2-5.5
Nitrites	1.5	0.02	75
Sodium ammonia	4.5 – 120	2	2.25 - 60
Fluoride	2	0.75	2.7

In the *raion* of Dangara, the only groundwater that is suitable for drinking water is in the northernmost part. The rest is too mineralized. Similar problems exist in the northern part of the country, where groundwater is characterized as mineralized and hard. For example, the cities of Khojent, Gafurov, Kanibadam and Isfara use water that is mineralized at 1 gram per liter (g/l), and has a hardness of as much as 4.3 times the MPC. The high concentrations of minerals and hardness are thought to be related to the irrigation regime. The mineralized water from the Syrdarya and highly mineralized drainage water used for irrigation leach into the groundwater and contaminate it.

Faizabad, Kuibyshev, Kalandash, Dashtirabad, Muminabad are the only areas that have high quality, uncontaminated groundwater for drinking water supplies.

Solid Wastes, Toxic, and Hazardous Materials

Calculations in 1998 show that more than 25 million tons of solid waste, more than 200 million tons of different types of industrial and mining wastes, and 20 million m^3 of liquid wastes were stored in Tajikistan. The majority of waste (77.1 percent) is produced by mining, 19.4 percent by minerals processing and municipalities, and the rest (3.5 percent) from other types of industry and human activities. Of the total produced, 1.4 percent is considered toxic or hazardous.

Despite the economic downturn, MOE reports that the amount of solid waste has increased. Experts attribute this growth to industrial processes that are becoming increasingly inefficient as equipment and technology deteriorates. However, given the increasing difficulties evidenced in collecting and treating wastes since independence, it can be inferred that accurately monitoring and quantifying wastes are equally problematic. In fact, MOE cites two main problems regarding the management of solid and hazardous wastes. First, lack of a database prevents officials from quantifying and cataloging types of wastes. Second, facilities for treating waste are either nonexistent (in the case of hazardous wastes) or in short supply (in the case of municipal solid wastes). Table 3.18 shows the amounts of solid wastes produced by location.

Table 3.18: Tons of Solid Wastes[a]
('000)

Region	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Leninabad	570	5,700	4,600	4,000	4,000	4,300	4,500	3,700	3,800	3,800
Khatlon	2,500	2,800	2,600	2,100	2,000	1,500	1,500	1,800	1,900	1,900
GBAO	539	689	600	510	590	630	650	689	800	800
RRS + Dushanbe	1,650	1,780	1,460	1,450	1,550	1,605	1,700	1,780	1,980	1,980
Total	**9,850**	**10,980**	**9,280**	**8,010**	**8,140**	**8,035**	**8,350**	**7,860**	**8,100**	**8,100**

Source: Ministry of Environment.

[a] It is noteworthy that there are discrepancies in data. Only the data in 1993, 1994, and 1995 add up to the amount given as total in the last line of the table. In most cases, the totals are higher and in one, lower, than the total given.

There are more than 400 sites that produce waste in Tajikistan. In addition to the sheer volume of waste, some enterprises produce toxic waste. Table 3.19 lists the enterprises that produce toxic wastes for which data are available.

Table 3.19: Forms and Amounts of Wastes by Factory

Enterprise	Form	Amount (tons)	Treatment (recycling)
Tajik Aluminum Plant	Carbon foam from processing	41,903	50% treated (reused)
	Sludge from smokestack	2,583	not used
	Coke dust	55,706	not used
	Residual from electrolyzer	26,111	10% recycled
Tajik Chemical Factory	Sodium hydrochloride	13,168	not used
Vaksh Nitrogen Fertilizer Plant	Spent catalysts containing nickel, iron, chrome, cobalt, and aluminum	545	not used
Tajik Cement Factory	Asbestos ash	200,000	5% used

Source: Ministry of Environment.

Table 3.20 shows the extent of resource recovery in the industrial sector.

Table 3.20: Average Annual Amounts of Wastes Recovered and Stored
(tons)

Industry	Annual Amount Recovered	Annual Amount Stored	Percent Recovered
Mineral ore (mining)	no data[a]	1,200,000	unknown
Chemical	no data	500	unknown
Textile	900	2,000	31
Machine-building	1,000	3,400	23
Construction	10,000	10,000	50
Food processing	5,000	5,000	50
Cotton processing	1,000	2,000	33
Metallurgy	85,000	550,000	13

Source: Ministry of Environment.

[a] The mining operation with the highest recovery rate is the Zeravshan gold mining operation.

Clearly, the recovery rate in some industries is higher than in others. Industrial processes are notoriously inefficient, but potential for recovery is quite high. However, as enterprises modernize within the context of a market-oriented economy, it is likely that there will be less waste per unit of product.

Many studies and recommendations have been made to increase recovery during the manufacturing process, but they lack economic analyses.

Toxic and Hazardous Wastes

It is estimated that of all the waste produced, 1.4 percent is toxic. Although a relatively small amount, it is waste produced in small quantities by numerous factories and plants, making their collection and treatment difficult. For example, approximately 50 plants have galvanizing processes that together produce 1,000 tons of wastes containing cadmium, cobalt, nickel, arsenic, and other elements.

Toxic and hazardous wastes typically are deposited either in state landfills or on the grounds of the plants where they are produced because there are no appropriate treatment facilities. In addition to the galvanic wastes, oil products, solvents, hospital wastes, varnishes, batteries, and fluorescent lights are placed in landfills and dumps. There are recorded incidents of agrochemicals being dumped in landfills, soils in mixing areas, and in waterways as well, particularly during the Soviet era when agrochemicals were widely used. By 1994, however, stocks of old stored agrochemicals were depleted and new supplies were available only in limited quantity. A site 40 km east of Dushanbe is used to store radioactive materials.[26]

Most of the hazardous wastes are generated by the mining industry. Because of inefficient mining methods, some mine tailings are estimated to contain as much as 5 to 10 percent useful materials. Heavy metals from mining such as zinc, cadmium, tungsten, molybdenum, sulfate, and mercury can be harmful to the environment when left exposed to water. Wastes from the Anzob processing plant contain sulfates, mercury, and antimony, while wastes from Adrasman contain lead, zinc, and cadmium. Wastes from the Leninabad rare metals plant contain tungsten, molybdenum, cobalt and nickel, while zinc and lead are found in the wastes from the Takob smelter. Failure to manage these wastes is believed to cause pollution in soils, groundwater, and in some cases, surface water.

Wastes are classified by toxicity. Tajikistan uses the system of four categories established during Soviet era. Class I is the most toxic, while Class IV is the least. Table 3.21 illustrates the types of classes and an example of waste found in each category.

Table 3.21: Waste Classifications and Related Storage

Class	Area Occupied	Type of Waste Stored
Class I	special storage facilities on enterprise and factory grounds	Example: mercury lamps (600,000)
Class II	12 hectares (ha) at Vaksh and Kanibadam landfills	Example: toxic chemicals (2.5 thousand tons)
Class III	total area unknown, but on the grounds of plants, enterprises	Example: slag from galvanizing process; 1.72 million tons of radioactive waste

[26] UNEP-GRID. *State of the Environment: Tajikistan 98*. 1998

Class	Area Occupied	Type of Waste Stored
Class IV	800 ha (22 tailings)	Example: 190 million tons of mining waste; 20 million tons of slurry
Total	1,100 ha	210 million tons

Class I: Extremely Dangerous
Class II: Highly Dangerous
Class III: Moderately Dangerous
Class IV: Slightly Dangerous

Municipal solid waste

Roughly 4 million tons of municipal solid waste (MSW) are produced annually. There are 70 official landfills[27] totaling 300 ha and an unknown, but growing, number of unofficial dumps in both urban and rural areas. The composition of MSW, shown in Table 3.22, is similar to that of other developing countries.

Table 3.22: Composition of MSW

Material	Percentage of Waste Stream
Food and kitchen wastes	45.0
Glass and ceramic	7.7
Plastics	17.3
Metals	5.0
Leather and resins	2.0
Paper and cardboard	11.0
Leaves and ash	12.0

Source: Ministry of Environment.

There are several negative aspects associated with MSW, as resources to collect and manage them have dwindled dramatically:

- Leachates from landfills and dumps are thought to adversely affect soils, groundwater, and surface water, but the extent of the problem has not been researched. None of the municipal landfills have monitoring wells.
- Landfills and dumps are often set on fire to reduce the volume. Fires create acrid smoke and present other hazards, particularly when they occur in highly populated, residential areas.

[27] The storage facilities are referred to as landfills by the Ministry of Environment, although they do not meet minimum international standards. None are lined, and management and monitoring technology is virtually nonexistent.

- Plastics and household toxic materials such as batteries, lamps, and containers of cleaning materials and automotive oils are regularly dumped. Smoke and leachates from these materials threaten environmental and public health.
- Scavengers mine dumps and landfills, running the risk of physical injury and contracting diseases.

SECTORAL IMPACTS

Each sector of Tajikistan's economy utilizes and impacts the natural environment. While many of the impacts have been discussed in previous sections, this section attempts to give more detail about the relationships between sectoral activities and environmental degradation.

Agriculture

Agriculture is the dominant sector of the economy, employing up to 50 percent of the population and contributing 28 percent GDP in 1998. As this section shows, performance in the agriculture sector decreased dramatically after 1991, but began to show signs of improvements in some areas.

Table A1.9 in Appendix 1, shows time-series data about the types of land uses by *oblast*. The table illustrates differences between regions in the country as well as changes in agricultural land use over time, based on the state-controlled land fund. The total land in the land fund (identified in the second column of the table) is that which is controlled by the Government and used for strategic purposes (see Table 2.2 in Chapter 2). Agriculture is the largest single land use, and details about agricultural land uses are given in the remaining columns of the table. Leninabad, Khatlon, and RRS all roughly had a ratio of cultivated land to pasture of 1:4. These three regions also show similar patterns in that the amount of cultivated and irrigated territories peaked in 1985 or 1990, shortly before independence. GBAO and RRS are different from the other three, but for different reasons. GBAO, because of its mountainous territory, has a much lower ratio of cultivated land to pasture, at roughly 1:50. RRS experienced maximum territories of cultivated, irrigated, and pastureland in 1970 (much earlier than the others), and declined thereafter. RRS, in fact, has shown the most dramatic decrease in territory characterized as cultivated, irrigated, and pastureland between peak years and 1998.

Since 1990, total land in the land fund decreased in Leninabad and Khatlon presumably through privatization. RRS and GBAO show an increase in territory in the land fund, despite countrywide privatization. Almost all types of land uses have decreased, except in Leninabad, where the total agricultural land has increased. Leninabad, the most stable *oblast* in the 1990s, also demonstrates the least decrease in cultivated and irrigated territory between peak years and 1998. Pastureland and land in perennials have in fact increased, reflecting and contributing to the relative well-being of the region. In Khatlon, on the other hand, cultivated and irrigated lands decreased by 31 percent and 35 percent, respectively. Land under hay decreased by roughly 40 percent, and pastureland decreased only slightly. Reasons for the dramatic changes in Khatlon can be partially attributed to the fact that the region witnessed heavy fighting and massive migrations of people in the early and mid-1990s. Secondly, few resources were available for maintenance of rural infrastructure. In RRS, the total land fund decreased by more than half between 1970 and 1985 for unknown reasons, and land under cultivation, irrigation, hay, and pasture decreased dramatically during that period. Between 1990 and 1998, however, the area of the land fund increased, while that cultivated, irrigated, perennials, and hay decreased only slightly. Pastureland increased, causing the total territory of lands designated as "agricultural" to increase. Land under cultivation and irrigation decreased by only 8 percent, perennials and hay decreased only slightly, and pastureland increased.

General trends are comparable between regions. Cultivated and irrigated lands decreased in the 1990s because of the civil war, mass migration of people, and lack of resources needed to work the land and maintain associated infrastructure. Land devoted to perennials increased, possibly because of low investment costs relative to rates of return. Pastureland increased in Leninabad and RRS, suggesting that even though the total official number of livestock decreased since 1990, herds under private management may have increased. Hay cultivation was down, which may have a detrimental effect on livestock health.

A more detailed breakdown by year and crop is found in Table 3.23.

Table 3.23: Lands Under Cultivation

Crop	1980		1985		1990		1992	
	ha	%	ha	%	ha	%	ha	%
Grains	44.6	8.8	57.7	10.7	71.7	12.5	95.5	17.3
Technical crops	313.9	62.1	316.9	58.6	309.1	54.2	291.7	52.8
Potatoes, vegetables and cucurbitz	18.2	3.6	23.3	4.3	33.6	5.9	27.5	5.0
Fodder	128.4	25.4	142.3	26.3	151.2	26.5	137.9	25.0
Total	**505.1**	**100**	**540.2**	**100**	**570.4**	**100**	**552.6**	**100**

Crop	1994		1995		1996		1997	
	ha	%	ha	%	ha	%	ha	%
Grains	105.3	19.5	122.4	23	154.9	31.4	172.3	36.1
Technical crops	287.7	53.4	283.1	53.5	230.0	46.7	219.8	46.0
Potatoes, vegetables and cucurbitz	26.4	4.9	24.7	4.7	16.5	3.3	14.7	3.1
Fodder	118.8	22.0	110.0	20.8	91.1	18.5	70.5	14.7
Total	**538.1**	**100**	**529.1**	**100**	**492.5**	**100**	**477.3**	**100**

Source: State Statistical Agency.

Total production peaked in 1990 at 570.4 thousand tons. The share of grain (mainly wheat) cultivated has increased dramatically, from 8.8 percent in 1980 to 36.1 percent in 1997. The biggest increase in wheat grown was in 1996, when the Government liberalized bread prices. Technical crops include cotton and tobacco. By 1997, area cultivated in cotton and wheat had decreased by almost 100,000 ha, or 70 percent of the area in 1980. Land under vegetable production has varied over the years, but reached a low in 1997 with 14.7 thousand ha, less than half of what was cultivated in 1990. The area devoted to fodder has decreased by more than half since 1990, which may have a detrimental impact on livestock health and numbers. The replacement of cotton with grains has positive environmental benefits, as grains do not deplete soil as severely. Tobacco is comparable to cotton in terms of its depleting effect on soil.

Table 3.24 further disaggregates the data.

Table 3.24: Land Under Cultivation (All Types of Farms)
(thousand ha)

	1992	1994	1995	1996	1997
Grain and legumes	263.8	254.7	264.9	383.6	418.7
—Wheat	183.4	177.2	191.4	279.9	356.4
—Barley	41.7	38.9	36.2	30.0	25.1
—Rice	10.5	13.4	12.8	11.5	15.1
—Legumes	11.3	10.2	9.9	34.8	11.3
—Other	16.9	15.0	14.6	27.4	10.8
Technical crops	297.2	299.7	284.9	240.0	236.0
—Cotton	285.3	281.0	268.4	228.2	218.6
—Fine fiber	40.8	40.4	43.2	41.1	32.2
—Oil-bearing crops	6.0	11.1	10.7	6.9	13.4
Potatoes	13.0	12.1	9.4	10.6	12.8
Vegetables	28.2	27.2	26.5	24.0	24.3
Cucurbitz family	8.6	9.7	9.8	7.7	9.5
Fodder	200.7	176.1	161.6	128.7	107.6
--Annual grasses	40.9	34.7	31.5	30.5	19.3
--Perennial grasses	116.8	103.7	97.4	76.6	73.3
--Silage crops (except corn)	2.4	2.2	1.6	3.0	2.5
--Corn	36.9	31.9	28.3	16.7	11.3
--Sugar beets (for feed)	1.9	1.2	0.9	0.8	0.5
Fruits and berries	80.4	85.1	96.4	93.2	71.0
Grapes	39.4	39.0	38.2	36.2	38.1
Total	812.0	780.0	757.9	795.4	809.4

Source: State Statistical Agency.

Tables 3.25 and 3.26 show the amounts and yields of the main crops between 1980 and 1997. Changes in tons produced roughly correlate with changes in area devoted to each crop. They also show the more dramatic phenomenon of decreasing yields. However, yields of grain and raw cotton showed improvements in 1996 and 1997, respectively.

Table 3.25: Crops
(thousand tons)

Crop	1980	1985	1990	1992	1994	1995	1996	1997
Grain (net weight)	245	326	318	276	229	249	548	559
—after processing	238	313	303	257	212	233	536	545
Raw cotton	1,011	935	642	514	531	411	318	353
—fine fibered	315	278	252	76	79	64	58	44
—processed (total)	321	291	252.5	174	170	125	95	106
Potatoes	153	185	207	167	135	112	108	128
Vegetables	381	473	528	543	495	491	397	351
Cucurbitz family	132	131	145	136	103	116	52	64

Source: State Statistical Agency.

Table 3.26: Crop Yields

(100 kg/ha)

Crop	1980	1985	1990	1992	1994	1995	1996	1997
Grain	12.1	15.2	13.7	10.4	9.0	9.2	14.1	13.1
—after processing	n/d	n/d	n/d	9.7	8.3	8.7	13.8	12.8
Raw cotton	32.8	30.1	27.7	18.0	18.9	15.3	13.9	16.2
—fine fiber	32.4	31.5	28.7	18.6	19.6	14.7	14.2	13.7
—processed	10.4	9.3	8.3	6.1	6.0	4.7	4.2	4.9
Potatoes	160	181	143	129	110	117	102	100
Vegetables	207	209	195	168	158	162	161	142
Cucurbitz	124	98	86	71	74	86	67	67

Source: State Statistical Agency.

Table 3.27 shows how areas under cotton cultivation and yields have changed. The lowest yields in Khatlon and Leninabad were in 1996. Lands devoted to cotton cultivation decreased by almost 20 percent in Khatlon, by 30 percent in Leninabad, and by almost half in RRS. Cotton cultivation has historically enjoyed a comparative advantage in Khatlon because of favorable climate and soil conditions, which explain why area under cotton cultivation decreased by the least percentage there.

Table 3.27: Raw Cotton Production by Region and Year

Year	Gross Production (thousand tons)	Area Under Cotton Cultivation ('000 ha)	Yield (100 kg/ha)
Khatlon *Oblast*			
1980	581.4	166.0	35.4
1985	542.9	162.2	33.3
1990	482.0	176.5	26.0
1992	295.5	178.4	16.6
1994	330.2	172.6	19.1
1995	224.4	166.3	13.5
1996	174.7	143.1	12.2
1997	186.8	136.8	13.6
Leninabad *Oblast*			
1980	263.4	91.8	28.7
1985	257.1	94.6	27.7
1990	247.8	89.9	27.5
1992	184.8	86.2	21.4
1994	154.6	84.6	18.2
1995	136.1	79.0	17.2
1996	100.3	64.6	15.5
1997	126.8	63.5	20.0
Regions under Republic Subordination			
1980	165.9	47.9	33.9
1985	135.0	54.4	24.8
1990	113.2	37.2	30.4
1992	34.60	20.6	16.8
1994	46.50	23.8	19.5
1995	50.30	23.1	21.7
1996	42.70	20.5	20.9
1997	39.70	18.3	21.8

Source: State Statistical Agency.

Agrochemicals

The prevailing view in Tajikistan is that agrochemicals are still the most effective means to protect crops from dangers and disease.[28] The proper application of pesticides, herbicides, and mineral resources results in yields that are thousands of tons greater than they would be otherwise. Officials concede, however, that improper transport, mixing, application, and storage of agrochemicals may directly damage human, livestock, and wildlife health and may also contaminate soil, water, air, and food supplies, negatively impacting health and productivity.

In recent years, lack of funds has resulted in a sharp drop in the availability of agrochemicals. In 1985, 18,805 tons of pesticides and 206,600 tons of mineral fertilizers were supplied. In 1995, 1,347 tons of pesticides and 32.3 thousand tons of mineral fertilizers were used, a decrease of 93 percent and 85 percent, respectively.

The average application rate for pesticides at the end of the 1980s was 16.5 kg/ha, and at some state farms in Kurgan Tyube, as high as 48 kg/ha. At that time, between 50 and 60 types of pesticides were used throughout Tajikistan. By contrast, the average application rate for pesticides in 1994 was 0.5 kg/ha, and in 1995, even less—0.3 kg/ha. The sharp decrease in application (by more than 15 times) has significantly reduced pesticide residues in soils.

Table 3.28: Agrochemical Use by Oblast and Year (tons)

Oblast	Year	Insecticide	Herbicide	Defoliant	Fungicide	Seed fumigation	Others	Total
Leninabad	1992	190	44	500	666	15	128	1,543
	1993	87	15	520	926	28	7	1,538
	1994	14.37	2.98		106			123.4
	1996	12						
Khatlon *Oblast*	1993	161	24	180	673	3	15	1,056
(Kurgan Tyube Zone)	1994	37.18	4.28	60	326	1	3.7	432.5
Khatlon *Oblast* (Kulyab Zone)	1994	34.75	4.33	0.5	714	9	3.5	766.5
RRS	1992	12		22		9	40	73
	1993	19		3	40	6	15	93
	1995	20.31	12.12	15	357.5	10.04	7.6	406.5
Total	**1992**	**202**	**44**	**500**	**688**	**24**	**168**	**1,616**
	1993	269	39	703	1,639	37	47	2,732
	1994	106.6	23.71	75.5	1,304	20.4	14.83	1,728.6
	1996	52.5						
	1997	35						
	1998				40	17		

Source: State Statistical Agency.

[28] Specialists at the Agricultural Sciences Academy voice alternative opinions about agrochemicals including integrated pest management and crop rotation.

Years for which no data were available were omitted from the table and blank cells indicate that no data were supplied. In GBAO, agrochemical use was always low, and reporting requirements were never enforced. Data are spotty in recent years, reflecting the fact that not only was agrochemical use low but also centralized procurement and reporting were abolished. Note that the data reported as totals for use throughout Tajikistan do not correspond with the sums of data from the *oblasts*. These discrepancies attest to the breakdown in procurement, control, and monitoring systems.

Irrigation and Drainage

Table 3.29 describes components of the irrigation and drainage system. Two-thirds of the canals are not lined, which accounts for the majority of water lost during conveyance. The conditions of the lined canals and raised troughs are poor, however, and much water is lost from them as well.

The drainage network has 37 percent the total length of the irrigation system. This low ratio of drainage to irrigation infrastructure contributes to salinity, erosion, and waterlogging problems.

Pumping is an important feature of the irrigation and drainage system. Officials at MOA estimate that 2 billion KW are required annually to power the pumps. In some places, water is pumped as high as 300 m. Many of the smaller pumps on vertical irrigation and drainage wells do not work. In places such as Asht *raion* in Leninabad which relies heavily on vertical drainage, the impacts on soil quality are dramatic. Of the 2,000 drainage wells in Leninabad, 1,000 currently do not function.

Table 3.29: Components of Irrigation and Drainage System

Component of System	Intra-farm Network	On-farm Network	Total
Irrigation (km)	**6,440**	**28,617**	**35,057**
Unlined trench canals	4,587	18,891	23,478
Lined canals	1,525	958	2,483
Raised troughs	262	2,696	2,958
Closed pipes	66	6,072	6,138
Drainage System (km)	**2,774**	**10,319**	**13,091**
On-farm drainage	472	1,254	1,724
Collector Drains	2,302	9,065	11,367
—Closed	946	3,733	4,679
—Open	1,356	5,332	6,688
Equipment for Systems (items)	**10,989**	**17,810**	**28,799**
Wells for irrigation	0	1,293	1,293
Wells for drainage	0	2,079	2,079
Pumping stations	445	0	4,45
Other	10,544	14,438	24,982

Source: Ministry of Water Resources.

Quality of Irrigated Lands

The extent of salination and the role that agriculture plays in creating it is discussed in Soil Erosion and Salination on page 25.

High water tables, sometimes created or exacerbated by poor drainage infrastructure, are often a precursor to salination. This is particularly true if groundwater is saline, the perched groundwater table is one meter or less, and capillary action fueled by evapotranspiration draws salts to the surface. Capillary action[29] in soils where groundwater is one to two meters from the surface may bring salts to the surface, but is also less likely to do so where groundwater is greater than two meters deep. Groundwater levels should be monitored, as groundwater levels three meters or less from the surface characterize nearly 30 percent of all irrigated lands, as Table 3.30 shows.

Table 3.30: Groundwater Depths, 1996
(thousand ha)

Region	Level of Groundwater			
	< 1 m	**1.0 – 1.5 m**	**1.5 – 2.0 m**	**2.0 – 3.0 m**
Leninabad	1,572	9,051	11,325	28,750
RRS	444	1,376	2,692	8,595
Khatlon	6,844	18,064	35,303	71,135
—Kulyab	870	5,460	12,180	12,210
—Kurgan Tyube	5,974	12,604	23,123	58,925
Tajikistan	8,860	28,491	54,330	117,480
Tajikistan (1995)	6,260	24,891	49,730	n/d
% increase, 1995-1996	29.4	12.6	8.5	

Source: State Statistical Agency.

Land quality, as defined by salination and/or high water tables, is depicted in Table 3.31. Lands of unsatisfactory quality are categorized in three different ways: high water table (but presumably no other significant problems), salinized (but no other significant problems), and combination (indicating the presence of high water table and salination). Not only does Leninabad has the highest percentage of unsatisfactory land (11.2 percent), but the lands in Leninabad seem to evidence the most advanced stages of land degradation, with higher percentages of unsatisfactory land due to combined problems of salination and high water tables. Lands in Khatlon tend to be degraded for singular reasons: either high water table or salination. RRS has a low rate of unsatisfactory territory (1.3 percent) and those lands tend to have high water tables, but few other problems.

[29] The hot, arid conditions typical of the agricultural lowlands of Central Asia raise evaporation and evapotranspiration rates and drive capillary action.

Table 3.31: Condition of Irrigated Lands by Oblast, 1998

Oblast	Total Irrigated Land (ha)	Good	%	Moderately Satisfactory (ha)	%	Unsatis-factory (ha)	%	High Water Table (ha)	%	Salinized (ha)	%	Combi-nation (ha)	%
Leninabad	259,317	190,884	73.6	39,360	15.2	29,073	11.2	13,339	45.9	8,192	28.1	7,542	25.9
Khation	321,007	222,025	69.2	66,491	20.7	32,941	10.1	17,430	52.9	13,788	41.8	1,723	5.2
RRS	100,029	97,336	97.3	1,353	1.3	1,340	1.3	1,287	96.1	0	0	53	3.9
GBAO	22,137	22,137	100.0	0	0	0	0	0		0		0	
Total	**702,490**	**532,382**	**75.7**	**107,204**	**15.3**	**63,354**	**9.0**	**32,056**	**50.6**	**21,980**	**34.7**	**9,318**	

Source: State Statistical Agency.

Table 3.32 shows the total lands abandoned each year because they are not fit to be cultivated. Comparing data on irrigated lands for 1998 between this table and Table A1.9 in Appendix 1 (History of Land Use in State-Controlled Land Fund by Year) show that in RRS 5 percent of lands were abandoned, 4.8 percent in Khatlon, 2.2 percent in RRS, and a surprising 36 percent in GBAO. Although land quality seems to be worse in Leninabad than in Khatlon, the amount of land abandoned is comparable. Factors contributing to land abandonment are salination, high water tables, debilitated irrigation and/or drainage infrastructure, and erosion.

Table 3.32: Abandoned Irrigated Lands

Region	1992	1993	1994	1995	1996	1997	1998
RRS	657	444	922	922	n/d	1,270	1,514
Leninabad	2,601	1,686	1,446	1,446	3,367	8,942	8,915
Khatlon	4,379	16,245	14,093	14,093	12,692	11,399	8,484
—Kurgan Tyube	2,575	15,787	13,060	12,434	12,463	10,798	7,882
—Kulyab	1,804	458	1,033	1,659	229	601	602
GBAO	275	2,470	3,755	3,755	3,755	6,605	5,638
Total	7,912	20,845	20,216	20,216	n/d	28,216	24,551

Source: State Statistical Agency.

Fisheries and Livestock

Fisheries never played a tremendous role in the agriculture sector, but were nonetheless part of the agricultural profile on the Obikhingau River of the Vaksh Basin and the Varzob River in the Kafernigan Basin. Commercial fishing was also popular in the Kairakum reservoir, but decreased from 192 tons in 1993 to 65 tons in 1997.

Livestock is an important facet of agriculture in Tajikistan. As Table 3.33 shows, official data indicate that livestock numbers have decreased. However, this table may not capture privately managed herds, which are reportedly on the rise. Livestock are blamed for overgrazing and erosion in mountainous areas. Neither the impacts of livestock nor the extent of overgrazing and erosion have been adequately studied, however.

Table 3.33: Livestock
(thousands of heads)

	1985	1990	1991	1992	1993	1994	1995	1996
Beef cattle	846	795	805	702	690	650	615	568
Milk cows	505	557	586	544	560	549	532	514
Pigs	205	183	128	56	46	33	6	2
Sheep	2,437	2,462	2,484	2,173	2,081	1,958	1,816	1,625
Goats	749	830	871	840	826	742	678	668
Horses	42	52	53	48	55	58	61	63
Total	4,784	4,879	4,927	4,363	4,258	3,990	3,708	3,440

Source: State Statistical Agency.

Transportation

Transportation infrastructure faces many challenges in Tajikistan, owing to the extreme topography and, in recent years, lack of funds for maintenance. The road network comprises roughly 10,000 km of paved highways, 2,600 km of gravel roads, 300 km of dirt roads, and 16,000 km of urban and private roads. There are 2,150 bridges, some of them spanning deep gorges. Roads, particularly in the mountainous parts of the country, are subjected to physical weathering and closure, either because of snow and ice or landslides. Steep slopes and fragile soils make road building and maintenance difficult. Two major roads are under construction now—one from Murgab in GBAO to Tashkurgan in western People's Republic of China,[30] and the other from Khorog to Kulyab along the Pyanj river. In many places they are being cut into the sides of mountains and road crews work under the constant threat of landslides.

The rail system comprises a total of 500 km of three unconnected lines in the western (populated) part of the country. Some officials register concern about pollutants emitted by diesel locomotives, but their impact on air quality is negligible.

While EIAs are reportedly carried out on road projects, impacts that the transportation network has on the environment are not monitored in Tajikistan. However, MOE reports that erosion from roads is noteworthy. Roads also provide access to isolated areas, which poses a threat to wildlife.

Mining

Very few data are available about mining sites and only anecdotal information is available about the environmental impacts. Seventy sites have been mined in Tajikistan, most of which have been open-pit. Reclamation activities are not practiced. Water erosion and riverbed sedimentation are two of the main problems. According to MOE, sedimentation has caused rivers to change course in some places, adversely affecting settlements and agriculture.

Mining is responsible for the majority of solid waste, producing 77.1 percent of the total. This represents a considerable amount of disruptive land-moving activity.

[30] Funded by the Islamic Development Bank.

Energy

Hydroelectric power dominates Tajikistan's energy sector. In 1997, hydroelectric power accounted for 98 percent of total primary energy production and about 80 percent of total primary energy consumption.[31] Table 3.34 details the electricity balance in Tajikistan.

Table 3.34: Electricity Balance (million KWh)

	1992	1995	1996	1997	1998
Electricity production	16,822	14,768	14,980	14,005	14,422
Imported electricity	6,428	4,860	3,978	4,345	3,969
Exported electricity	5,596	4,198	4,890	4,247	3,724
Electricity demand	17,654	15,430	14,068	14,103	14,667
Industry and construction	9,866	6,701	5,425	5,023	5,154
Transport	82	80	71	71	67
Agriculture	4,270	4,565	4,158	4,354	4,471
Other	1,565	2,290	2,364	2,606	2,882
Transmission losses	1,871	1,794	2,050	2,049	2,093

Source: State Statistical Agency.

Table 3.34 is striking in several ways. First, demand exceeds not only production, but also supply. Second, the amount lost in transmission is greater than the difference between supply and demand. Third, it shows that the industrial sector accounted for 20 percent of GDP and uses 35 percent of electricity in 1997. Agriculture provides 28 percent GDP and accounts for 30 percent of electricity consumed. The "Other" category includes municipal use. With severe reduction in availability of gas and central heating, many households have been turning to electricity for cooking and heating, partially accounting for the 5 percent increase in share consumed between 1992 and 1998.

Energy consumption in the industrial sector, in particular, has decreased markedly since 1992. Table 3.35 shows that 1998 consumption levels were at 54 percent of 1992 levels, underscoring the dire contraction of industrial production. Energy consumption in Tajikistan is dominated by the light metallurgy subsector, representing 87 percent of electricity consumption in 1998. The Tajik aluminum plant alone consumes 40 percent of electricity in Tajikistan. Aluminum processing is extremely energy-intensive, and Soviet planners identified Tajikistan as the ideal location for it because of the availability of hydropower. Chemical and petrochemical manufacturing and light industry, which represent the next largest share of consumption, together utilize only 8 percent of the amount used by the light metallurgical subsector.

Table 3.35: Energy Consumption by Industry
(million kWh)

	1992	1994	1995	1996	1997	1998
Heating	33.6	20.8	16.8	13.7	10.7	8.6
Light metallurgy	7,157.0	15,393.0	5,142.0	4,357.0	3,959.0	4,158.0
Chemical and petroleum refining	455.0	224.0	226.0	136.0	142.0	139.0
Machine building and metalworking	361.0	453.0	940.0	114.0	64.0	89.0
Woodworking	10.9	7.6	3.8	3.0	1.6	2.3

31 ADB. *Economic Report and Interim Operational Strategy for Tajikistan*. August 1998.

	1992	1994	1995	1996	1997	1998
Building materials	139.0	94.0	63.0	46.0	28.0	37.0
Glass and porcelain	24.2	17.8	16.5	8.4	8.5	8.5
Light	408.0	318.0	279.0	200.0	192.0	196.0
Food processing	130.0	110.0	83.0	67.0	52.0	60.0
Total	**8,971.0**	**6,802.0**	**6,876.0**	**5,008.0**	**4,567.0**	**4,788.0**

Source: State Statistical Agency.

Very little thermal energy is produced in Tajikistan (see Table 2.4), and data are not available about the environmental impacts of such facilities. Nine hydropower stations generate all of the electricity in the country, and no data were available describing the environmental impacts caused by the facilities. Given the high rate of erosion, reservoirs may risk sedimentation.

The main environmentally related problem associated with energy is the high degree of waste. Soviet industrial, agricultural, and even municipal technologies are infamously inefficient and, because cost-recovery was not widely practiced, few incentives existed to engage in conservation. The Government is now committed to a reform program that includes raising tariffs on electricity to improve cost-recovery.

Industry

Previous sections discuss the impacts that industry has on land, air, and water resources. Cattle and dairy plants, cement factories, fertilizer and chemical enterprises, and metallurgical plants (particularly the Tajik aluminum factory) count among the most polluting industries. Impacts of industry are distributed unevenly, mirroring the general development pattern. While some mineral processing plants are located in somewhat remote areas, most industries are near population centers in the western part of the country. Table 3.36 shows the distributions by *oblast* and shows the concentration of industry in the entire western portion of the country. Data about RRS, aside from Dushanbe, are not available. The Tajik aluminum plant is in Tursunzade in the far western part of RRS. The Takob ores processing plant is another sizeable metallurgical enterprise located in RRS.

The preponderance of machine building and metalworking enterprises, which were identified by MOE as being polluting and difficult to control, are concentrated in Leninabad and Khatlon *oblasts*. The table also underscores the low industrial level of GBAO.

Metallurgical enterprises produce tremendous quantities of solid waste that often contain hazardous elements. Concerns associated with the storage of such wastes include soil, groundwater, and surface water contamination from heavy metal leachates. Some of them also produce air pollutants such as fluoride, hydrogen fluoride, phenol, formaldehyde, and ammonium, cyanide oxide, and chlorine.

Other industries such as cement plant, chemical and petrochemical enterprises, and food processing enterprises are also identified by MOE as industries of environmental concern.

Table 3.37 identifies the principal point-source polluters for surface and groundwater resources. Although MOE considers them to be significant point-source polluters, no data were available about the exact nature or quantities of pollutants produced.

Table 3.36: Profiles of Regions by Type and Number of Industry

Leninabad			Khatlon			GBAO			City of Dushanbe		
Type of Industry	**1997**	**1998**	**Type of Industry**	**1997**	**1998**	**Type of Industry**	**1997**	**1998**	**Type of Industry**	**1997**	**1998**
Electricity stations	4	4	Electricity stations	6	6	Electricity stations	1	1	Electricity stations	4	5
Heating plants	3	3	Heating plants	3	3	Machine building & metal working	2	2	Chemical & petrochemical	5	5
Light metallurgy	7	8	Chemical & petrochemical	2	2	Building materials	1	1	Machine building & metal working	30	36
Chemical & petrochemical	3	3	Machine building & metal working	126	201	Light industry	1	1	Wood products/cardboard	10	10
Machine building & metal working	101	88	Building materials	19	26	Food processing	2	2	Building materials	20	19
Wood products/ cardboard	28	21	Light industry	29	41	Others	1	1	Light industry	21	25
Machine building & metal working	58	50	Food processing	62	50	Total	8	8	Food processing	17	17
Light industry	45	50	Flour mills and processing	136	87				Flour mills and processing	1	1
Food processing	103	93	Others	30	39				Others	22	21
Flour mills and processing	61	71	Total	413	455				Total	130	139
Others	46	35									
Total	459	426									

Source: State Statistical Agency.

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Table 3.37: Main Point-Source Polluters

Basin and Polluter	Potential Contaminants[32]
Kafernigan Basin	
Wastewater treatment facilities in Shartuz, Gissar, Dushanbe, Kofarnikhon raion, and poultry plant	*e.coli*, heavy metals, nutrients
Cattle and dairy plant in Kabodion raion	Nutrients, possibly disease (leptospirosis)
Khodji Obi Garm health resort	Nutrients
Cement plant in Dushanbe	Alkaline effluents
Agricultural runoff	High mineral content; potential agrochemical contamination
Vaksh Basin	
Wastewater treatment facilities in Kurgan Tyube (2), Khodjamaston, Nurek	*e.coli*, nutrients, heavy metals
Vaksh nitrogen fertilizer plant	Nitrogen compounds
Cattle and dairy plant in Khodjamaston	Nutrients, possibly disease (leptospirosis)
Yavan chemical plant	Not available
Central wastewater collector drain	Nutrients and minerals, possibly agrochemical contamination
Agricultural runoff	Nutrients and minerals, possibly agrochemical contamination
Zeravshan Basin	
Anzob gold processing plant	Mercury
Syrdarya Basin	
Wastewater treatment plants in Kairakum, Khujand	*e.coli*, nutrients, heavy metals
Food processing plants in Kanibadam, Isfara, Proleterask, Gafurov	Nutrients, *e.coli* (meat processing),
Chemical plant in Isfara	Not available
Metallurgical plant in Isfara	Heavy metals
Furniture factory in Khujand	Solvents
Porcelain factory in Khujand	Not available

Source: Ministry of Environment.

[32] Taken from the *Pollution Prevention and Abatement Handbook: Towards Cleaner Production*. The World Bank Group in collaboration with UNIDO, UNEP, and WHO. 1998.

Table 3.38 identifies the most significant point source air polluters.

Table 3.38: Emissions from Major Stationary Sources, 1998

Plant/Factory	Pollutant	Tons/Year
Tajik Aluminum Factory	Carbon monoxide	14,408
	O_x	150.593
	Fluoride	350.0
	Hydrogen fluoride	122.1
Vostokredmet	Carbon monoxide	561.995
	O_x	86.165
	Phenol	0.01
	Formaldehyde	1×10^{-6}
	Fluoride	0.105584
Vaksh Nitrate Fertilizer Factory	Carbon monoxide	4,244.01
	O_x	289.4
	Ammonium	178.74
Isfara Metallurgy Factory	Carbon monoxide	5.162
	O_x	4.8556
	Cyanide oxide	0.0243
	Chlorine	0.1199
Dushanbe Heating & Power Plant	Carbon monoxide	1,354.352
	O_x	744.48
	Fluoride	0.0065

Source: Ministry of Environment.

According to officials at MOE, improved implementation of pollution control measures accounts for some of the decrease in emissions. A notable investment in pollution control equipment for two of the stacks at the Tajik Aluminum plant was made in 1998 at a cost of US$200,000. They note also that the general decrease in production and economic activity is probably the most important factor in the decrease in pollution.