necessary to reclaim land under such severe conditions; since reclamation will also take a significant amount of time, the farmers' burdens are great after purchasing such land.

From our field study, we were also able to verify that some landless farmers who did not received a distribution purchased sections of land from those who did and have reclaimed this land with bulldozers. Despite the fact that bulldozers are indispensable to reclaiming such inhospitable land, it is difficult for the impoverished, landless farmers to afford even the nominal rental fee charged for use of a bulldozer, making it a challenge for them to reclaim all of the land at once after purchasing it.

Consequently, since they cannot afford to reclaim all of the land at one time, the impoverished farmers are reclaiming it in small sections (of approximately 0.5 to 1.0 ha) as they manage to save the money needed for bulldozer rental.

Section 2.3: The Appropriateness of Agricultural Land Development

Subsection 2.3.1: Natural Conditions

In the 79.61 million hectares of its lands, the country of Pakistan contains many regions with distinctive characteristics: the towering mountains of the Himalayas and Karakorum, permanent glaciers, the fertile reservoirs of the Indus River Region, deserts and plateaus. Eighty percent of the total land area is arid or semi-arid, 12 percent semi-wetland, and the remaining 8 percent wetlands. The seasons are divided between summer and winter.

Viewed from an agricultural/biological perspective, Pakistan's National Action Program for Arid Land Development and Combating Desertification in Pakistan divides the country's lands into seven areas. The special characteristics of Pakistan's land are indicated in Charts 2, 4, and 5 in the Appendix, according to landform, land quality, natural vegetation, and soil type.

1. Northern mountain region
2. Barani rainwater-fed region
3. Irrigated plains
4. Sandy deserts
5. Land irrigated by floodwater from the Sulaimann Rod Kohi mountain chain
6. Western dry mountain region
7. Coastal regions

The issues attendant to each of the regions are noted below:

1. Northern mountain region
   The main water sources are the Tarbela Dam and the Mangla Dam; however, severe erosion has caused sediment to accumulate in the reservoirs, resulting in decreased capacity for electricity generation and insufficient water for irrigation.
2. Barani rainfall region

This region consists of rain-fed fields (without irrigation); severe soil erosion is occurring due to crop cultivation, livestock pasturage, and illegal harvesting of plants.

3. Irrigated plains
   With the highest level of agriculture, this region is the country's grain belt. Although falling in the arid to semi-arid climactic zone, this region has the world's most extensive network of irrigation canals, fed by five rivers, including the Indus River. However, progressive devastation of this region has been caused by the dual disasters of flooding and damage due to salinification.
4. Sandy deserts
   This region is prone to the problems of shifting sand dunes and damage due to salinification.
5. Land irrigated by flood water originating from the Sulaimann mountain chain
   This region irrigates with the floodwaters from the Sulaimann mountain chain. The crops and homes of this region have become susceptible to flooding due to failures in soil conservation.
6. Western dry mountain region
   Groundwater supplies are scarce in the western mountainous region of Balochistan; this has only been exacerbated by excessive use due to gardening and crop cultivation. Productivity remains low due to the demands of livestock.
7. Coastal regions
   Severe wind erosion, water erosion, and shifting sand dunes threaten to bury the harbor, roads, homes, and other infrastructure; a severe lack of drinking water is now a problem.

The table on the next page details the special characteristics of the seven regions.

Table 2-9: Classification & Defining Characteristics of National Lands from an Agricultural/Biological Perspective

	Agricultural Classification						
	Northern Mountain Region	**Barani Region[3]**	**Irrigated Plains**	**Sandy Deserts**	**Sulaiman, Rod, & Kohi Regions[4]**	**Western Dry Mountain Region**	**Coastal Region**
Area (km^2)	115,340	51,600	165,300	132,700	41,690	333,800	38,750
Elevation (m)	1,000-8,600	250-900	25-250	50-1,000	250-2,500	1,000-2,500	0-1,000
Population (millions)	7.8	10.9	66.0	5.00	4.00	13.8	12.5
Climate	• Dry to humid • Subtropical to alpine	• Semi-arid to semi-humid • Subtropical	• Extremely arid to semi-arid • Subtropical	• Extremely arid to semi-arid • Subtropical	• Arid to semi-arid • Subtropical	• Extremely arid to semi-arid • Subtropical to temperate	• Extremely arid • Tropical
Soil	• Mountain slopes: shallow, unstable soils • Valleys: stable, deep loamy soil	• Deep silt • Loamy; part clay and part sand	• Deep loamy soil • Part clay • 5.2 million ha salty • 2.2 million ha immersed	• Sand • Partially loamy and sandy	• Deep loamy soil • Part gypsic/saline	• Almost no soil in the mountainous region; plateaus of soil in fan-shaped valleys	• Diverse
Ownership	• Primarily small-scale, individually owned • Publicly held • Nationally held	• Primarily small-scale, individually owned • • Publicly held • Nationally held	• Primarily small-scale, individually owned •	• Nationally held land • Publicly held land • Parts privately owned	• Nationally & privately held • Mixture of large-and small-scale holdings	• Publicly held • Most nationally held, parts privately held	• Most publicly held • Parts privately held

[3]Barani Region: Rain-fed agricultural zone
[4]Rod & Kohi are arid regions with occasional rivers; there are sudden rapids following hard rains. River flow depends on the condition of the area, but happens only a few times per year, following hard rains.

	Agricultural Classification						
	Northern Mountain Region	**Barani Region[3]**	**Irrigated Plains**	**Sandy Deserts**	**Sulaiman, Rod, & Kohi Regions[4]**	**Western Dry Mountain Region**	**Coastal Region**
Major Industries	• Forestry • Livestock grazing • Fruit growing • Wildlife • Tourism	• Livestock raising • Crop cultivation on arid lands	• National grain belt • Agriculture	• Livestock raising • Firewood & charcoal for fuel	• Livestock raising • Date palms • Minimal farming	• Livestock raising • Gardening • Mining • Gas	• Fishing • Ship dismantling • Date palms/coconuts • Livestock raising, tourism, salt
Vegetation	• Conifers 900m in height or more; broad-leafed trees beneath this	Oleo Acacia Prosopis sineraria Zizyphus mauritiana	Salvadora Prosopis Acacis Dalbergia	Prosopis cineraria Tamarix aphylla	Prosopis cineraria Tamarix aphylla	Juniper Artemesia Haloxylon Tamarix aphylla	Prosopis cineraria Acacia jacquemontii A.senegal Maerua Mangroves
Wildlife	Marcopolo sheep Markhor Ibex Snow leopard Barking deer Goral musk deer Pheasants	Urial Chinkara Seesee Chukar Partridges	• Black and gray partridge • Migratory birds	Black buck chinkara sandgrouse bustards partridges	Chinkara bustards sand grouse	Markhor Sind ibex urial partridges houbara bustard	Chinkara, urial sindh ibex waterfowls crocodiles green turtle
Problems attendant to development	• Decreasing vegetation on slopes • Top soil erosion • Loss of soil nutrients • Decreases in productivity • Leaching of nutrients in wetlands • Cultivation of steep slopes • Road	• Soil erosion • Loss of soil nutrients • Erosion of small rivers & narrow ravines • Death of arbors & run-off of topsoil	• Damage from salinification • Flooding • Lack of water for irrigation • Groundwater salinification	• Wind erosion • Irrigated lands being buried due to shifting sand dunes • Decreasing diversity of wildlife • Seasonal food shortages • Drinking water shortages	• Flooding • Lack of drinking water • Soil erosion • Decrease in forests • Loss of diversity in wildlife	• Deterioration of livestock pasturelands • Drying up of groundwater • Decline of Chinese Juniper forests	• Severe wind erosion • Water erosion • [Damage to] harbors from shifting sand dunes • Roads • Houses • Danger of other infrastructure being buried • Serious drinking water shortages

	Agricultural Classification						
	Northern Mountain Region	**Barani Region[3]**	**Irrigated Plains**	**Sandy Deserts**	**Sulaiman, Rod, & Kohi Regions[4]**	**Western Dry Mountain Region**	**Coastal Region**
	construction on unstable slopes • Waste • Landslides						
Options for avoiding problems	• Reforestation to preserve soil & water quality • Improve land use patterns & social infrastructure • Plant vegetation & trees on slopes • Establish fruit storage & marketing facilities	• Soil & water conservation • Social range management • Plant a diverse variety of trees • Improvements to & preservation of forests • Agroforestry	• Build water canals • Re-evaluate sewage system • Restore land damaged by salinification & flooding • Plant trees • Agroforestry	• Stabilize shifting sand dunes • Secure water sources • Restore decimated pasture lands • Plant trees in arid regions	• Manage irrigation for Rod & Kohi • Promote fruit from arid regions that doesn't rot easily • Manage livestock grazing , agroforestry	• Revive pasturelands • Conserve groundwater • Secure surface water • Mining	• Stabilize sand dune • Plant trees for forage • Plant shrubs • Secure surface ground water • Agriculture on salinified lands • Control use of groundwater • Sustainable management of mangroves

Source: Arid Land Development and Combating Desertification in Pakistan: National Action Program; http://www.shonan.ne.jp/~gef20/desert/joyaku/nappaki.html#1

The conditions in each province are noted below.

1) Punjab Province

Excluding the Northern Region with its elevations of over 1,000 meters, the majority of Punjab Province lies in arid to semi-arid climactic zones. Yearly rainfall in the north ranges between 250-500 mm; in the south, it ranges between 125-250 mm. Most of the rainfall occurs during the monsoon season, from July through September.

The northern region is mountainous with elevations exceeding 1,000 meters; this changes as we progress south to the foothills (300-500 meters), to the central river region (150-300 meters), and to the southern foothills (75-150 meters). There are expansive desert regions in the central region and southeastern regions of the province; it is these desert lands that are being considered for future agricultural development. Natural conditions for these regions are indicated in Charts 1 through 5 in the Appendix.

We have summarized conditions noted during our field surveys below:

- Southeastern Region of the Province

  There are no formal planning documents for the three districts, including Bahawalpur; however, these areas are being targeted for the future cultivation of cotton. They are intending to reclaim desert land and make it suitable for agriculture. We conducted a field survey of one section of this region. Although the area they are intending to reclaim is desert, irrigation canals have been built in the vicinity. These simple, dugout irrigation canals fulfill the role of monitoring groundwater levels and show that the groundwater table is relatively high. The next projected development of a desert region (locally known as "Great Cholistan") is subject to severe climactic conditions (the temperature exceeds 50º C in the summer). The water to be used for irrigation is expected to be groundwater, but the water table is far below ground, at a depth of 24-37 meters. Chart 6 in the Appendix show the quality of groundwater and the manner in which it is allotted.

  During our field survey, we were also able to see the actual results achieved in converting desert to agricultural land through the initiative of Pakistan's own efforts; however, the crop yields per unit area for the cotton and wheat primarily cultivated in this region were below average for the province; the yields were 75 percent and 60 percent of provincial averages, respectively.

2) Sindh Province

Sindh Province lies in the hilly region in the foothills of the Kirthar mountain chain along the western border of Balochistan Province. The eastern section bordering India is a desert region, with the Indus River stretching north to south between these two borders forming an alluvial plain. Irrigation canals have been constructed on the left bank of the Indus River.

The natural conditions for this region are shown in Charts 1 through 5 in the Appendix. The conditions noted during our field survey are summarized below.

- The Vicinity of the Indus River

  We toured an agricultural development site near the Kotri Bridge in Sindh Province. This was originally an Indus River alluvial plain and the land is fertile. Since the Indus River runs nearby, it is comparatively easy to obtain water for irrigation. Since this region lies on the lower course of the Indus River through Sindh Province, it is relatively easy to obtain water, except for the regions lying at the foothills in the southwest and the desert region to the south.
- The Northern Section of the Province

  We surveyed the land reclaimed under the jurisdiction of the northern repair facilities (in Sukkur and Khairpur). The land near these facilities was stony and sandy, but the desert had been converted to agricultural land by obtaining water from a water canal built on a level with the cultivated land. Cotton and wheat are grown here. We anticipate an increase in reclaimed land due to the construction of water canals. Both areas we visited were equipped with shallow and hand-pump wells; we surmise from the use of these kinds of wells that the water table is at a depth of less than 10 meters. We expect the groundwater is being fed by simple dugout irrigation canals.

3) Balochistan Province

Geographically speaking, Balochistan Province lies in an arid to semi-arid region and covers an area roughly equivalent to that of Japan. It is difficult to secure water supplies in this region.

Although this region has high potential as land for agricultural development, there are problems with securing water sources following development due to its natural conditions, as shown in Charts 1 through 5 in the Appendix.

Since use of scarce rainfall is a determining factor in this region, crop cultivation is largely influenced by terrain. This region is divided into sloping land that is infertile due to the run-off or influx of rainwater, low-

lands with abundant vegetation, and flat plains in the foothills and valley basins. The breakdown of these is as follows:

Foothills	51.7%
Fan-shaped gravelly soil	21.5%
Mountain foothill plains	11.6%
Desert	7.5%
River plains	2.8%
Other	4.9%

Source: Fundamental Survey and Report on Plans for Obtaining Equipment for Agricultural Development in Balochistan Province, in the Islamic Republic of Pakistan; January 1994

Unlike the provinces of Punjab and Sindh, Balochistan does not have any specialized industries, so it is difficult to find income sources other than those of the agriculture and livestock industries.

Due to these conditions, the only means available to increase the income of the people living in this region is to increase the unit yield or the agricultural land area, or to increase income earned from the livestock industry. Both of these alternatives require more water for irrigation than has been used up to this point.

We summarize our notes from the site surveys below.

- Region Surrounding Quetta

  The surrounding regions of Quetta that we surveyed were those irrigated by rainfall. This was accomplished by building a low embankment comprised of earth and stone (the surface layer was gravel) to avoid loss of rainfall, plus a floodwater irrigation region which collects run-off from the rainfall that occurs once or twice yearly in a small facility. These facilities serve to prevent the loss of the region's precious rainwater resources and to prevent soil erosion. Since it is difficult to build these facilities with a wheeled tractor, bulldozers are indispensable.

  The progressive lowering of the groundwater table in the regions surrounding Quetta is becoming problematic. Since the set fee for use of groundwater is Rs 4,000/month, groundwater is used for quantities needed in excess of that used for irrigation. This has already been specified as one factor for the lowering of the water table.

- Southwestern Section of the Province

  Turbat, located in the southwestern section of the province, was reclaimed as an experimental agricultural site for the provincial government, by removing the stony surface layers. The water source for this region is groundwater; water is pumped at the rate of 1

m^3/sec from a depth of approximately 90 meters. The depth of the water table has been increasing each year.

A seasonal river (i.e., present only during the monsoon season) flows through this area; if a facility were built to harvest this seasonal river flow as a groundwater source, it could contribute to water supplies. The foremost desire of the local people is apparently a check dam.

The Mirani Dam is also under construction in this district; so future supplies of water for irrigation are anticipated.

4) North-West Frontier Province

The NWFP is the most impoverished of the four provinces. There are no specialized industries other than agriculture and livestock, so income sources for the residents are limited.

Lying in the arid to semi-arid climactic zones, water supplies are scarce in this province, save for the mountainous region. Consequently, the use of rainfall is vitally important to the entire province. Seasonal rainfall is comparatively frequent in July and August (the monsoon season) and in the winter months of January and February. The natural conditions for the province are shown in Charts 1 through 5 in the Appendix.

The local people wish to build small-scale facilities such as check dams, small reservoirs and mini dams to make use of rainwater. These facilities are usually constructed with technological assistance from the Agricultural Bureau, and by individual farmers renting materials and equipment such as bulldozers.

Points from our onsite survey are summarized below.

- Area surrounding Peshawar

The individual sites we toured were high plateaus and are gradually being reclaimed by using bulldozers to level the terraces. According to the landowners, drinking water and water for irrigation is obtained from groundwater supplies; the depth of the water table is usually about 75 meters, but has reached 150 meters in recent years due to drought.

After reclaiming the land, the farmers excavate wells for groundwater and install pumps to draw up the water; however, this requires money for electricity fees. According to the landowners, it takes approximately ten years to derive a profit from produce (vegetables) planted on reclaimed land, since they must recover their investments in land reclamation, well construction, pump installation, and electricity expenses.

Pakistan has always struggled to operate an agricultural industry under the natural conditions of a severe climate. They have continued to convert land to agricultural uses under these same severe conditions; the land remaining is considered to be subject to even more severe conditions.

Pakistan currently supports a population of 140 million people; this is increasing by just under 2 percent per year. In order to resolve the threat of population pressures and ensure adequate food supplies, we consider the following two measures essential: 1) increased yields per hectare, and 2) the expansion and improvement of agricultural lands.

Table 2-10, below, shows the yield per hectare of wheat for each province from 1998-1999 to 2002-2003. On average, this has been 2.5 tons/hectare over the most recent five-year period for Punjab and Sindh provinces, Pakistan's major provinces for agriculture. This level is close to that of world averages (See Chart 2-1, below: Trends in Wheat Harvest Yields for Major Countries); it is equivalent to levels achieved by the major wheat-producing countries. Conversely, yields are below 2.0 tons/hectare for the NWFP and Balochistan Province, where natural conditions are severe. It will not be easy to raise yields higher than this for either province since they already have yields equivalent to the world average for reclaimed agricultural land and have limited access to water sources. To achieve yields higher than this would require the yearly purchase of high-quality seeds and fertilizer, securing sufficient water for irrigation, and improving farming methods. Although the initial purchase of these things is feasible for farming households that already have income from a certain level of operations, such investments would be difficult for small-scale farmers not gifted with these conditions. Therefore, we believe the key to increasing yields is to expand the available agricultural land, rather than to increase yields per hectare.

Chart 2-2, below, shows trends in agricultural lands and wheat production revenues, including trends in quantities of wheat produced, total area of croplands, total area of irrigated lands, and population, as well as future projections for these items. In this table, the population growth rate up to this point and the quantity of cropland and wheat produced have kept pace, showing similar curves. While population growth is expected to follow similar trends, it will be a challenge to ensure adequate food supplies unless the quantity of wheat produced increases similarly. It will therefore be difficult to maintain current conditions. Expanding available agricultural lands is essential, since increasing yields is problematic.

Table 2-10: Wheat Harvests by Province (Unit: tons/ha)

Fiscal Year	Punjab Province	Sindh Province	North-West Frontier Province	Balochistan Province	Total for Pakistan
98/99	2.2	2.3	1.4	2.4	2.2
99/00	2.7	2.6	1.3	1.6	2.5
00/01	2.5	2.7	1.0	1.9	2.3
01/02	2.4	2.4	1.2	1.9	2.3
02/03	2.5	2.4	1.5	1.9	2.4
Average	**2.5**	**2.5**	**1.3**	**1.9**	**2.3**

Source: Pakistan Agricultural Statistics, 2002-2003; Pakistan Ministry of Food, Agriculture & Livestock, Economics Department

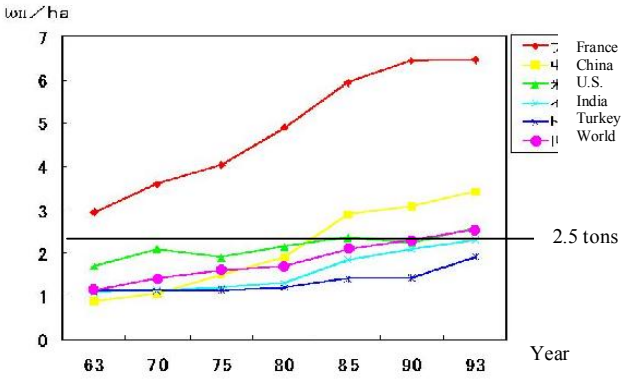

Chart 2-1: Trends in wheat yields per hectare for major countries
(from the FAO Production Yearbook)

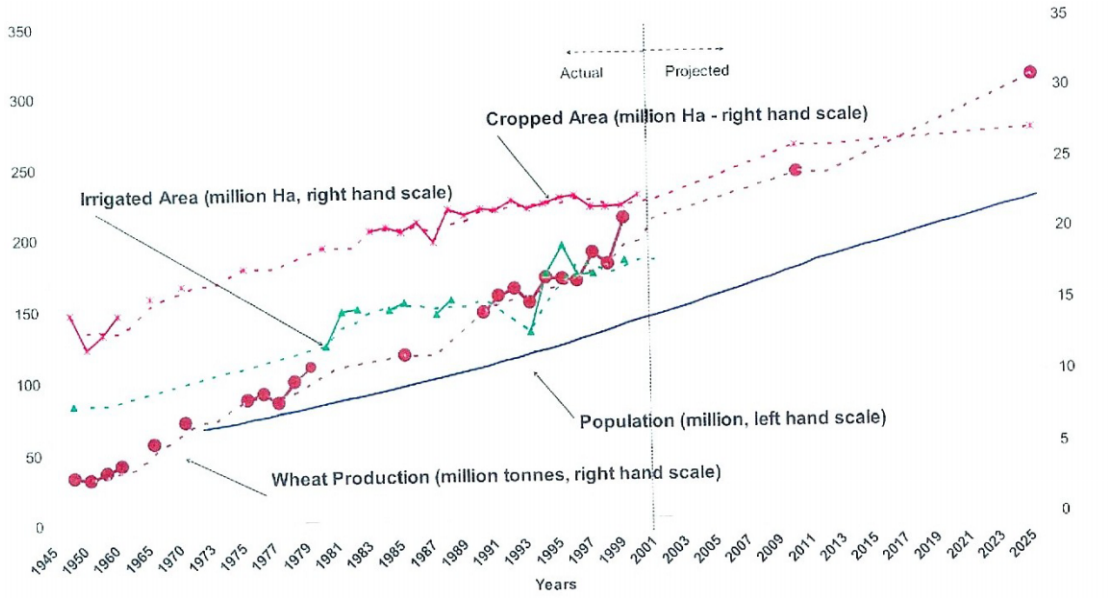

Chart 2-2: Trends in population, agricultural lands, and wheat production revenues
Source: Pakistan Water Sector Strategy (on a more detailed basis)

Subsection 2.3.2: Beneficiaries

The agricultural machinery repair facilities controlled by the Machinery Division of each province's Agricultural Bureau mainly handle repairs for comparatively smaller bulldozers used in agricultural development (reclamation and leveling), boring machines for groundwater wells, and automobiles. They also rent bulldozers and boring machines to farmers for a fixed rental fee.

Rentals are handled by collecting rental fees in advance for the number of hours the farmers will use the bulldozers. As a rule, bulldozers are rented out only after advance payment is received; there have, however, been occasions where they have had to accommodate politicians or people of influence in the region.

Although the repair facilities can determine the amount of time a bulldozer will be needed when a farmer submits a rental request, they cannot determine the area of the cropland or harvest yields, which would offer a yardstick for measuring the farmers' prosperity. Pakistan has a tribal or familial social structure; a single person will often request bulldozer time required for the number of people in their entire social structure. This is one reason why it is difficult to determine the circumstances of the persons benefiting from the bulldozers.

The rental records for Punjab Province up to this point are relatively accurate; these are shown below. Since statistics by cropland area and the size of lands owned by the renters are not kept for the other three provinces of Sindh, Balochistan and the NWFP, such information is unclear and highly unreliable.

Table 2-11: Rental Records for Punjab Province

(# of farmers by size of land owned)) (Unit: # of people)

Fiscal Year		Area of Land Owned (acres)				Total
		A<2ha	2ha≦A＜5ha	5ha ≦ A < 10ha	10ha≦A	
July 1999-June 2000		2,716	3,812	2,704	1,567	10,799
July 2000-June 2001		1,694	2,584	2,003	1,321	7,602
July 2001-June 2002		2,147	3,052	2,297	1,530	9,026
July 2002-June 2003		2,417	3,417	3,032	1,489	10,355
July 2003-June 2004		2,378	3,433	2,606	1,562	9,979
Total	# of farming households using bulldozers (1)	11,352 (23.7%)	16,298 (34.1%)	12,742 (26.6%)	7,469 (15.6%)	47,861 (100%)
Total # of farming households in Punjab Province (by area of land owned) (2)		2,165,122 (56.0%)	1,134,718 (29.4%)	368,156 (9.5%)	196,072 (5.1%)	3,864,068 (100%)
% with access to bulldozers (1) / (2)		0.05%	1.44%	3.46%	3.80%	

Source: Punjab Province, Agricultural Field Management Division* 2000 Agricultural Census for Punjab Province

The rental results for Punjab Province for the most recent five years give the ratio of bulldozer usage time as 6:4 for farming households owning less than 5 hectares of land (defined in Pakistan as small-scale farmers) to those owning over 5 hectares. In absolute numbers, the rental ratio is higher for small-scale farmers.

However, when we compare the ratio of farming households renting to the ratio of land area owned province-wide, the bulldozer rental ratio increases in proportion to the amount of land owned, as seen above. The most prosperous are, therefore, deriving the most benefit from bulldozer rental services. Moreover, the probability that farming households owning less than 2 hectares of land will be able to gain access to bulldozers is 0.52 percent; indicating that few of the farming households in this category actually benefit from bulldozer rental services.

The poverty rate for Pakistan is shown below. Among those owning land less than 2 hectares in size, differences in the poverty rates by land area are small; all are above 30 percent. For those owning over 2 hectares of land, poverty rates show a decreasing trend.

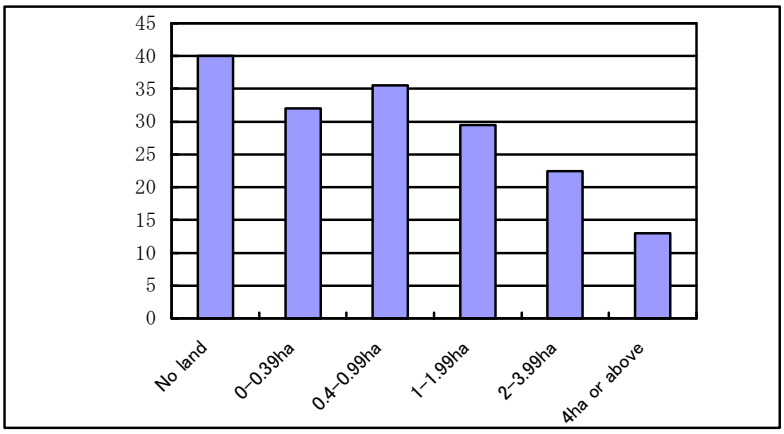

Chart 2-3: Poverty rates according to area of land owned by farming households

From the above chart, we can see that many of the farming households owning 2 hectares or less of land live in poverty, making it difficult for them to rent bulldozers.

Therefore, we cannot expect that the bulldozer rental system will only directly benefit the poor. However, our interviews during field surveys made it clear that we can expect some indirect benefits to those in poverty since large-scale farmers will experience an increase in demand for farm workers as they reclaim agricultural land, thereby creating new employment opportunities.

All provinces currently rent bulldozers to all farmers on a subsidized basis under fixed conditions. This factors into the inability to maintain machinery on an ongoing basis since the Agricultural Machinery Division cannot recover enough to pay their administrative expenses for continual oversight.

When, in the course of our field survey, we proposed to the authorities of a certain regional office in Punjab province that they offer special rental rates to those using significant bulldozer time or those who were well-off, they informed us that when they had tried setting higher rental rates for those who were well-off, they people then submitted requests under the names of small-scale farmers, so conditions did not improve. Consequently, it would be difficult to change rental fees from an operational standpoint.

Below, we show water resource development plans as well as the projected area of land to be reclaimed and the projected number of beneficiaries per district in each province, as estimated from unused cultivable land currently owned by farming households.

1) Beneficiaries of large-scale water resource development plans

As noted above, the Pakistan Water and Power Development Authority (WAPDA) is pursuing plans for water resource development, so the number of beneficiaries can be estimated from this plan. These plans also include the total amount of reclaimed agricultural land. No data based on actual results have been prepared with regard to the percentage of land that will need to be reclaimed or lev-

eled by bulldozer once the facility is finished. According to our oral survey, the percentage of reclamation and leveling to be done by bulldozer is between 30 and 100 percent, with 50 percent or 30 percent typical amounts. We have therefore used 50 percent and 30 percent to calculate the values below. The number of beneficiaries was calculated from the average amount of land owned in the province in which they live.

Table 2-12: Number of Beneficiaries According to the Water Resource Development Plans Implemented by the Federal Government (only for the provision of water for irrigation)

Project Name	Province Located In	Land Area Irrigated[5] (ha)	Area Requiring a Bulldozer for Reclamation or Leveling (ha)		Avg. Lan Area Owned (ha)	Projected Number of Beneficiaries (# of people)	
			50%	30%		50%	30%
Greater Thal Canal	Punjab	631,332	315,666	189,400	2.9	108,850	65,310
Bulldozer time required (millions of hours)			(19.6)	(11.7)			
Rainee Canal	Shindh	123,197	61,598	36,959	4.0	15,400	9,240
Bulldozer time required (millions of hours)			(0.7)	(0.4)			
Kachi Canal	Balochistan	288,551	144,276	86,565	7.8	18,497	11,098
Bulldozer time required (millions of hours)			(2.4)	(1.4)			
Sabkzai Dam	Balochistan	10,118	5,059	3,035	7.8	649	389
Bulldozer time required (millions of hours)			(0.08)	(0.05)			
Mirani Dam	Balochistan	13,436	6,718	4,031	7.8	861	517
Bulldozer time required (millions of hours)			(0.1)	(0.07)			
Gomal Zam Dam	N.W.F.P	65,966	32,983	19,390	1.7	19,402	11,641
Bulldozer time required (millions of hours)			(0.5)	(0.3)			
Kurram Tangi	N.W.F.P	34,197	17,099	10,259	1.7	10,058	6,035
Bulldozer time required (millions of hours)			(0.3)	(0.2)			
Satpara Multipurpose Dam	Jammu and Kashimir (Skaradu Town)	8,062	4,031	2,418	7.8	517	310
Bulldozer time required (millions of hours)			N.A.	N.A.			

Source: Vision 2025: Development of Water Resources and Hydro-electric Power; Preparatory Study Team derived from WAPDA sources

[5]We believe that "area irrigated" includes both privately and publicly owned land. Details were unavailable for this study.

2) Beneficiaries in Punjab Province

The nature of the use of agricultural land owned by farming households in each district of Punjab Province are shown in the table below. There are 439,511 hectares of cultivable land currently owned by farming households that is not yet being used and will need to be reclaimed or leveled by bulldozer. This comprises around 24 percent of the total unused cultivable land in the entire province, an estimated 1.8 million hectares. Moreover, the 439,511 hectares of unused uncultivable land is owned by farming households in districts under the jurisdiction of these repair facilities; this does not represent the entire area of currently unused cultivable land in the entire province. The total area of unused cultivable land for the province as a whole is 464,026 hectares.

Table 2-13: How Land is Used by Farming Households in Each District of Punjab Province (districts with repair facilities only)

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5	6:(8+10)	7	8	9	10
	Entire Province		3,864,068	11,235,313	10,295,447	659,385	939,866	270,619	464,026	443,003	475,840
1 Bahawalpur	1	Bahawalpur	148,632	882,343	863,915	28,208	18,428	5,457	6,267	24,240	12,161
	2	Rahim Yar Khan	189,861	1,176,332	1,149,436	35,605	26,896	10,648	12,131	26,575	14,765
	3	Bahawalnagor	138,248	1,239,310	1,188,320	28,033	50,990	15,247	27,642	14,285	23,348
		Cholisatan	13,984	151,912	139,263	8,574	12,649	3,939	7,988	6,977	4,661
	Total		490,725	3,449,897	3,340,934	100,420	108,963	**35,291**	**54,028**	72,077	54,935

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5	6:(8+10)	7	8	9	10
	Entire Province		3,864,068	11,235,313	10,295,447	659,385	939,866	270,619	464,026	443,003	475,840
2 Multan	4	Multan	103,092	347,053	317,899	14,435	29,154	5,207	9,939	9,904	19,215
	5	Khanewal		335,254	327,155	16,668	8,099	2,871	3,184	14,029	4,915
	6	Vehari	119,576	339,380	333,544	15,246	5,837	3,222	2,763	12,293	3,073
	7	Sahiwal	99,330	233,315	228,220	11,603	5,095	3,568	2,650	8,349	2,445
	8	Lodhran	77,561	222,739	215,085	17,315	7,654	2,874	3,030	15,236	4,624
	9	Pakpattan	78,566	216,495	212,335	5,016	4,160	1,464	1,790	3,613	2,370
	10	D.G. Khan	97,464	295,083	261,257	15,322	33,826	8,733	24,227	6,693	9,599
		De-Ex.Area of D.G. Kahan	14,243	19,930	17,795	1,864	2,135	889	1,138	1,104	997
	11	Muzaffargarh	109,789	1,474,239	1,352,076	67,706	122,163	22,416	37,599	52,829	84,563

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5	6:(8+10)	7	8	9	10
	Entire Province		3,864,068	11,235,313	10,295,447	659,385	939,866	270,619	464,026	443,003	475,840
3 Faisalabad	12	Rajanpur	89,607	313,101	258,292	13,059	54,809	10,946	48,248	2,471	6,561
		De-Ex. Area of Rajanpur	1,002	3,174	2,996	117	178	75	176	41	2
	13	Layyan	109,786	432,528	396,419	45,051	36,109	12,493	16,351	36,651	19,758
	Total		1,019,044	4,232,291	3,923,074	223,402	309,218	**74,758**	**151,095**	163,213	158,123
	14	Faisalabad	184,377	371,642	358,160	16,816	13,483	11,998	11,569	5,404	1,914
	15	Jhang	185,671	665,854	623,144	34,214	42,710	10,355	19,102	26,819	23,608
	16	Toba Tek Singh	83,556	212,561	205,140	11,576	7,422	4,522	5,701	7,168	1,721
	17	Sargodha	359,999	1,612,393	1,590,369	61,293	22,024	5,380	12,120	13,467	9,904
	18	Khushab	70,213	386,814	373,162	7,651	13,652	4,639	10,435	3,383	3,217

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5	6:(8+10)	7	8	9	10
	Entire Province		3,864,068	11,235,313	10,295,447	659,385	939,866	270,619	464,026	443,003	475,840
	19	Bakkar	102,315	546,154	526,849	19,515	19,305	5,366	10,407	15,287	8,898
	20	Mianwali	71,363	316,354	275,646	16,325	40,708	7,341	20,550	9,346	20,158
	Total		1,057,494	4,111,772	3,952,469	167,390	159,303	**49,601**	**89,883**	80,874	69,419
4 Lahore	21	Lahore	31,686	83,671	79,919	1,453	3,752	925	1,997	631	1,755
	22	Sheikhupura	149,070	433,394	415,697	9,828	17,697	7,362	13,740	2,892	3,957
	23	Kasur	117,823	300,015	290,905	5,306	9,110	3,052	5,949	2,884	3,161
	24	Okara	117,632	315,889	301,228	10,450	14,661	6,033	7,953	4,690	6,708
	25	Gujranwala	86,530	275,810	268,186	2,939	7,625	1,874	5,736	1,115	1,889
	26	Hafizabad	39,874	147,470	140,484	3,485	6,986	2,512	5,577	1,136	1,409

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5	6:(8+10)	7	8	9	10
	Entire Province		3,864,068	11,235,313	10,295,447	659,385	939,866	270,619	464,026	443,003	475,840
5 Talagang	27	Mandi Bahauddin	70,338	198,522	188,347	13,597	10,175	4,677	4,881	9,122	5,294
	28	Sialkot	119,369	196,381	192,086	2,777	4,295	1,234	2,000	1,550	2,295
	29	Gujrat	141,138	187,366	170,889	19,712	16,476	13,041	10,547	8,185	5,929
	30	Narowal	87,402	160,003	150,843	6,777	9,160	4,083	4,984	2,795	4,176
	Total		960,862	2,298,521	2,198,584	76,324	99,937	**44,793**	**63,364**	35,000	36,573
	31	Chakwal	112,153	400,364	309,261	36,276	91,104	19,344	37,441	26,459	53,663
	32	Jhelum	69,197	394,712	10,196	25,195	50,198	11,686	21,547	17,283	28,651
	33	Attock	111,302	389,225	306,432	31,282	82,793	14,026	23,466	24,119	59,327
	Total		292,652	1,184,302	625,889	92,753	224,095	**45,056**	**82,454**	67,861	141,641

Source: 2000 Agricultural Census for Punjab Province

Ranking the projected frequency of use for the repair facilities resulting from the reclamation of unused cultivable land owned by farming households, as

noted in the water resource development plans outlined in 1) above: Multan ranks first; Faisalabad second; Talagang third; Lahore fourth; and Balawalpur fifth.

Furthermore, we have calculated the operational time required for bulldozers under the jurisdiction of each repair facility (workshop) from the actual operational time required for bulldozers (on average) per unit of land cultivated.

Table 2-14: Area of Unused Cultivable Land Owned by Farming Households & Projected Operational Time for Bulldozers (Punjab Province)

Rank	Name of Repair Facility	Unused Cultivable Land (ha)	Operational Time Required Per Hectare (hr/ha)	Water Resource Development Plans & Regions Being Developed; Unused Cultivable Land Area (ha)	Operational Time (millions of hours)
1	Multan	151,096	62	Of the 4 districts involved in the Greater Thal Water Canal Project, the district of Layyah is subject to jurisdiction. 16,351 ha total	9.4
2	Faisalabad	89,883	62	Of the 4 districts involved in the Greater Thal Water Canal Project, the 3 districts of Bakkar, Khushab and Jhang are subject to jurisdiction. 39,944 ha total	5.6
3.	Talagang	82,454	62		5.1
4.	Lahore	63,364	62		3.9
5.	Bahawalpur	54,028	62		3.3
	Total	**439,511**			**27.2**

3) Beneficiaries in Sindh Province

The area of unused cultivable land owned by farming households in each of the districts under the jurisdiction of the repair facilities studied in Sindh Province is shown below. There are a total of 303,313 hectares of unused cultivable land currently owned by farming households, which farmers will need to reclaim with bulldozers. This comprises around 24 percent of the 1.27 million hectares of unused cultivable land in the entire province. These 303,313 hectares are unused cultivable land owned by farming households in districts under the jurisdiction of the repair facilities studied; they do not represent the total area of unused cultivable land in the province as a whole. There are 968,918 hectares of unused cultivable land provincewide.

Table 2-15: How Land is Used by Farming Households in Each District of Sindh Province (districts with repair facilities only)

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area(ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5	6:(8+9)	7	8	9	10
	Entire Province		1,069,882	4,324,848	3,253,934	238,308	1,070,914	211,924	968,918	38,953	101,996
1 Tandojam	1	Hyderabad	75,460	321,754	259,436	17,003	62,318	13,417	45,769	5,398	16,549
	2	Sanghar	96,169	311,518	276,107	10,154	35,411	9,474	33,335	1,061	2,076
	3	Mirpurkhas	38,742	302,059	191,800	19,735	110,259	17,684	99,634	5,605	10,625
	Total:		210,371	935,330	727,343	46,892	207,988	**40,575**	**178,738**	12,064	29,250
2 Khairpur	4	Khairpur	114,011	248,931	236,636	7,098	12,295	5,949	9,748	2,380	2,548
	5	Nawabshah	50,230	180,946	158,548	22,937	22,398	21,666	20,885	1,437	1,513
	6	Nosherofe-roze	49,349	215,868	151,845	10,601	64,023	9,918	61,040	1,046	2,983
	Total		213,590	645,745	547,029	42,396	98,716	**37,533**	**91,672**	4,863	7,044
3 Sukkur	7	Sukkur	29,562	91,830	90,052	541	1,777	393	1,506	151	272

8	Shikarpur	50,793	139,827	138,584	106	1,242	106	1,242	-	-
9	Landkhot	Included with Jacobabad								
10	Jacobabad	64,924	269,303	246,592	8,314	22,711	7,277	19,919	1,328	2,792
11	Ghotki	74,495	191,874	172,761	11,095	19,112	7,648	10,236	3,447	8,876
Total		219,774	692,833	647,990	20,056	44,834	**15,424**	**32,903**	4,926	11,940

Source: 2000 Agricultural Census for Sindh Province

Ranking the projected frequency of use for repair facilities due to unused cultivatable land owned by farming households which is reclaimed and due to water resource development plans: Tandojam ranks first; Sukkur second; and Khaipur third. For Sukkur, this will be minimal, judging from the reclaimed area of unused cultivable land owned by farming households; however, two districts involved in the Rainee Canal Project, those of Gotki and Sullur, are under the jurisdiction of the repair facilities. Once this project has been completed, we foresee increased demand for land development among the farming households of this region. The area to be irrigated by this project is 123,197 hectares; however, there are 32,903 hectares of unused cultivable land that can be newly developed, so 400 thousand hours of bull-dozer operation time will be needed to develop the land for agriculture.

Below, we have calculated the operational time required for bulldozers under the jurisdiction of each repair facility (workshop) from the (average) operational time required for bulldozers per hectare of land.

Table 2-16: Area of Unused Cultivable Land Owned by Farming Households & Projected Operational Time Required for Bulldozers (Sindh Province)

	Name of Repair Facility	Unused Cultivable Land (ha)	Operation Time Required Per Hectare (hr/ha)	Water Resources Development Plans That will be Completed in the Near Future & Regions Involved in Development; Unused Cultivable Land Area (ha)	Operational Time (millions of hours)
1	Tando Jam	178,738	11.4		2.0
2	Sukkur	32,903	11.4	Of the two districts involved in the Rainee Canal Project, Gotki and Sukkur districts are subject to jurisdiction. 11,742 ha total	0.4
3	Khairpur	91,672	11.4		1.0
	Total	**303,313**			**3.4**

At the time of the study, a protective escort was needed to conduct a field survey of the repair facilities and reclaimed land due to political unrest.

4) Beneficiaries in Balochistan Province

The table below shows the nature of land usage for land owned by farming households in each district under the purview of the repair facilities in Balochistan Province subject to this study (all districts). There are 1,109,926 hectares of unused cultivable land currently owned by farming households, which it will be necessary to reclaim or level with bulldozers for use as agricultural land. This comprises around 23 percent of the total 4.84 million hectares of unused cultivable land in the province as a whole. The 1,109,926 hectares of unused cultivable land is owned by farming households in districts under the jurisdiction of the repair facilities subject to this study; it does not represent the total area of unused cultivable land in the entire province. There are 1,110,039 hectares of unused cultivable land throughout the province.

Table 2-17: How Land is Used by Farming Households in Each District of Balochistan Province (districts with repair facilities only)

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5:(7+8)	6:(8+9)	7	8	9	10
	Entire Province		329,868	2,585,000	1,271,631	174,518	1,313,369	129,851	1,110,039	44,667	203,442
1 Quetta	1	Quetta	3,650	49,016	17,125	2,374	31,892	1,804	28,201	767	3,691
	2	Pishin	19,839	121,745	62,215	13,755	59,530	8,000	39,995	9,193	19,534
	3	Killaabdullah	15,514	92,189	44,460	7,293	47,729	5,525	40,204	4,571	7,525
	4	Chaghi	8,241	156,731	46,895	7,373	109,835	4,809	67,703	2,650	42,132
	5	Loralai	19,394	192,105	81,749	11,274	110,355	8,723	7,324	3,374	23,031
	6	Barkhan	3,754	21,950	18,071	877	3,878	740	3,015	218	863
	7	Musa Kheli	2,037	7,074	6,288		786	62	451	253	335

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5:(7+8)	6:(8+9)	7	8	9	10
	Entire Province		329,868	2,585,000	1,271,631	174,518	1,313,369	129,851	1,110,039	44,667	203,442
	8	Zhob	18,464	52,033	23,114	10,128	28,919	9,431	27,799	957	1,120
	9	Killa Saifullah	14,315	76,794	35,576	7,630	41,218	7,314	39,470	1,781	1,748
	10	Sibi	7,206	60,968	46,177	2,371	14,791	2,339	14,271	78	521
	11	Ziarat	5,225	5,089	4,622	366	467	270	361	97	106
	12	Kohlu	5,606	30,295	23,291	2,772	7,005	2,318	5,604	753	1,400
	13	Dera Bugti	4,577	32,618	24,326	721	8,292	614	6,495	422	1,798
	14	Nasirabad	18,943	171,101	137,375	1,153	33,726	1,029	32,259	124	1,467
	15	Jaffarabad	25,830	154,365	144,454	1,208	9,912	1,143	8,666	65	1,245

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5:(7+8)	6:(8+9)	7	8	9	10
	Entire Province		329,868	2,585,000	1,271,631	174,518	1,313,369	129,851	1,110,039	44,667	203,442
4 Khuzdar	16	Jhal Magsi	15,269	142,686	80,546	6,734	62,140	6,615	56,327	2,323	5,812
	17	Bolan (Kachhi)	17,871	212,361	59,103	8,982	153,258	6,254	108,318	2,758	44,940
	Total:		205,735	1,579,120	855,388	85,484	723,732	**67,190**	**566,463**	30,384	157,269
	18	Mastung	24,122	96,689	52,279	15,062	44,410	10,967	38,894	4,439	5,516
	19	Kalat	18,041	161,867	64,815	9,746	97,052	9,244	94,974	1,103	2,079
	20	Khuzdar	27,546	201,487	108,230	11,587	93,257	9,970	70,533	3,822	22,724
	21	Awaran	3,599	74,100	9,169	1,003	64,931	982	64,863	25	68
	22	Kharan	10,473	145,211	48,800	5,976	96,411	5,884	88,519	943	7,892
	23	Lasbela	17,822	135,142	40,319	14,555	94,823	13,839	90,920	3,109	3,903
	Total		101,603	814,497	323,612	57,929	490,885	**50,886**	**448,703**	13,441	42,181

Workshop	District Name		Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
	1		2	3:(4+6)	4	5:(7+8)	6:(8+9)	7	8	9	10
	Entire Province		329,868	2,585,000	1,271,631	174,518	1,313,369	129,851	1,110,039	44,667	203,442
3 Turbat	24	Turbat	15,850	124,591	67,108	7,834	57,483	7,705	57,152	159	331
	25	Gawadar	2,521	30,896	1,877	2,482	29,019	2,155	26,532	453	2,488
	26	Panjgur	4,708	35,896	23,646	2,145	12,250	1,915	11,076	230	1,174
	Total:		23,079	191,384	92,631	12,461	98,752	**11,775**	**94,760**	842	3,992

Source: 2000 Agricultural Census for Balochistan Province

Ranking the projected frequency of use for repair facilities due to unused cultivatable land owned by farming households being reclaimed and due to water resource development plans: Quetta ranks first; Turbat second; and Khuzdar third.

Below, we have calculated the operational time required for bulldozers under the jurisdiction of each repair facility (workshop) from the (average) operational time required for bulldozers per hectare of land.

Table 2-18: Area of Unused Cultivable Land Owned by Farming Households & Projected Operational Time Required for Bulldozers (Balochistan Province)

	Name of Repair Facility	Unused Cultivable Land (ha)	Operation Time Required Per Hectare (hr/ha)	Water Resources Development Plans That will be Completed in the Near Future & Regions Involved in Development; Unused Cultivable Land Area (ha)	Operational Time (millions of hours)
1	Quetta	566,463	16.3	Of the four districts involved in the Kachi Canal project, all four fall under the jurisdiction of the repair facilities: Jafarabad, Nasirabad, Jhal Magsi, and Bolan. The one district involved in the Sabkzai Dam falls under this jurisdiction. 205,570 ha + 27,799 ha = 233,369 ha total	9.2
2.	Turbat	94,760	16.3	The one district of Turbat, which is involved in the Mirani Dam project, falls under this jurisdiction. 57,152 ha total	1.5
3	Khuzdar	448,703	16.3		7.3
	Total	**1,109,926**			**18.0**

A field survey of the Khuzdar repair facility and the reclaimed land surrounding it was not possible due to issues of political unrest. The only access to Khuzdar is by land. Political unrest is still more a problem in this region than at the other two locations. A security escort accompanied us for our field surveys of the other three locations as well.

5) Beneficiaries of the North-West Frontier Province

The table below shows the nature of land usage for land owned by farming households in each district under the jurisdiction of the repair facilities in the NWFP subject to this study (i.e., every district). There are a total of 206,604 hectares of unused cultivable land currently owned by farming households, which it will be necessary to reclaim through use of bulldozers for use as agricultural land. This comprises about 17 percent of the 1.25 million hectares of unused cultivable land in the province as a whole.

Table 2-19: How Land is Used by Farming Households in Each District of the North-West Frontier Province (districts with repair facilities only)

Workshop		District Name	Total Farming Households		Cultivated Agricultural Lands	Agricultural Land Not Being Cultivated					
						Total		Unused Cultivable Land		Land Unsuitable for Cultivation	
			# of farmers (# of people)	Area (ha)	Area (ha)	# of farmers (# of people)	Uncultivated Land (ha)	# of farmers (# of people)	Area (ha)	# of farmers (# of people)	Area (ha)
		1	2	34+6)	4	5	68+9)	7	8	9	10
		Entire Province	1356280	2,263,336	1,657,665	373,875	605,671	147,184	328,154	267,215	277,517
1 Peshawar	1	Peshawar	45,015	48,543	47,938	571	605	436	535	136	71
	2	Nowshera	42,319	42,592	40,742	3,456	1,850	2,717	1,527	992	323
	3	Charsadda	45,242	64,868	64,389	457	479	250	404	208	74
	4	Mardan	62,459	92,312	90,179	3,917	2,133	971	1,663	2,994	470
	5	Swabi	65,085	71,376	70,518	1,639	858	657	229	1,093	628
	6	Haripur	66,758	89,942	53,044	31,751	36,898	8,697	9,152	25,829	27,745
	7	malakand	10,211	12,807	12,293	796	514	165	136	636	378
	8	Swat	69,099	64,936	60,122	5,495	4,814	2,281	2,889	3,306	1,925
	Total		406,188	487,377	439,225	48,082	48,151	**16,174**	**16,536**	35,194	31,616
2 D.I.Khan	9	D.I. khan	46,473	354,107	168,826	24,068	185,281	20,953	167,842	4,515	17,439
	10	Tank	11,994	57,466	47,262	2,117	10,203	2,028	9,510	167	693
	11	Lakki Marwat	36,998	186,321	172,258	4,259	14,063	3,156	11,699	1,796	2,364
	12	Bannu	37,420	46,914	45,682	4,108	1,233	1,298	429	3,492	804
	13	Karak	30,959	123,477	112,060	4,693	11,417	4,465	7,620	410	3,797
	14	Kohat	33,285	36,926	35,257	1,926	1,669	895	823	1,208	846
	Total		197,129	805,210	581,346	41,171	223,865	**32,795**	**197,923**	11,588	25,942

Source: 2000 Agricultural Census for the North-West Frontier Province

Ranking the projected frequency of use for repair facilities due to unused cultivatable land owned by farming households being reclaimed and due to the water resource development plans noted in subsection 2.2.2: D.I. Khan ranks first; Peshawar second.

Below, we have calculated the operational time required for bulldozers under the jurisdiction of each repair facility, or workshop, from the (average) operational time required for bulldozers per hectare of land.

Table 2-20: Area of Unused Cultivable Land Owned by Farming Households & Projected Operational Time Required for Bulldozers (North-West Frontier Province)

	Name of Repair Facility	Unused Cultivable Land (ha)	Operation Time Required Per Hectare (hr/ha)	Water Resources Development Plans That will be Completed in the Near Future & Regions Involved in Development; Unused Cultivable Land Area (ha)	Operational Time (millions of hours)
1	D.I.Khan	197,923	16.3*	The D.I. Khan district, which is involved in the Gomal Zam Dam project, falls under this jurisdiction. The district of Banuu, which is involved in the Kurram Tangi Project, falls under this jurisdiction. 167,842 ha + 429ha = 168,271 ha total	3.2
2	Peshawar	16,302	16.3*		0.3
	Total	**206,604**			**3.4**

Note: Values for Balochistan Province applied.

As can be seen from the table above, it will require over 3 million hours to prepare the unused cultivable land owned by farming households. However, the two repair facilities noted above have only ten operable bulldozers. Furthermore, our field survey made it clear that all of these bulldozers are barely operable and are very likely to break down during operation. Due to this, it will be difficult to develop the unused cultivable land in the NWFP.

The timing of the study coincided with the mop-up campaign to wipe out the Taliban, so the Pakistani military was attacking strongholds found in certain tribal lands. There was concern that the Taliban were scattered around the environs of D.I. Khan; therefore, it was impossible to carry out the study. Should these conditions continue, it will be impossible to implement improvements for the repair facilities. China is apparently constructing a dam near the D.I. Khan region using BOT methods (Build, Operate and Transfer); however, it is unclear what construction materials and equipment are being used.

Cropland as a percentage of the land in each province is indicated in Chart 7 in the Appendix.

Subsection 2.3.3: Crops Expected to be Cultivated Following New Development and their Influence on the Japanese Agricultural Industry

The unused cultivable land expected to be developed from this point onward is land that had been impossible to reclaim, due to the difficulty of obtaining water for irrigation and the scarcity of necessary materials and equipment for reclamation, such as bulldozers. Apart from some small-scale vegetable farming post-reclamation, crops requiring large quantities of water will not be feasible.

Below, we have listed the major crops being cultivated on reclaimed land, determined from our oral survey of people about local reclaimed land.

Table 2-21: Major Crops Expected to be Cultivated Following Agricultural Land Development

Major Crops Projected for Cultivation	Province	Region
Wheat	Punjab Province	Northern region & areas surrounding Multan
	Balochistan Province	Area surrounding Quetta
Cotton	Punjab Province	Southern region
	Sindh Province	Southern & northern regions
Sugarcane	Punjab Province	Area surrounding Multan
Vegetables	North-West Frontier Province	Area surrounding Peshawar
Date Palms	Balochistan Province	Southeast region
Rice	Balochistan Province	Southeast region

Pakistan's rice crops are paddy rice; judging from the conditions stated above, the percentage cultivated following new land reclamation should be low. The major crops are wheat and cotton; we do not expect the crop area devoted to rice cultivation to expand much. Based on this, we do not foresee an increase in rice exports following the new development of agricultural lands.

There will be little competition with Japanese farmers over wheat, cotton, sugarcane, and date palms.

We will show agricultural exports of Pakistan during the last five years by way of reference. According to these statistics, the representative exports crops are rice, wheat, and cotton.

Table 2-22: Trend in Quantities of Agricultural Products Exported

(Unit: 1,000 tons)

FY Name of Agricultural Product	1998-99	1999-00	2000-01	2001-02	2002-03
Major Agricultural Products					
Cotton	4.2	85.8	176.6	38.0	55.1
Cotton waste	61.9	83.8	97.4	97.1	93.5
Raw wool	2.7	2.0	1.5	1.7	2.8
Fish	79.1	89.9	82.0	84.4	94.6
Rice (Total)	1,788.8	1,916.1	2,294.3	1,684.3	1,820.0
Basmati rice	588.8	569.8	502.1	550.0	716.7
Other rice	1,200.0	1,346.2	1,792.2	1,134.3	1,103.3
Fruits	180.8	239.7	259.9	289.6	263.1
Honey	0.8	0.7	0.5	0.4	1.1
Vegetables (excluding 1 & 2)	192.0	228.2	152.5	134.0	186.3
Potatoes (1)	121.3	91.1	58.5	57.0	69.3
Onions (2)	67.8	128.7	77.2	53.4	63.7
Peppers	0.9	1.7	3.3	1.3	3.6
Other varieties	-	-	6.5	4.8	5.3
Castor oil	1.1	1.1	*	2.3	0.9
Cumin, caraway seed	0.7	4.0	0.5	0.6	0.7
Poppy seeds	7.4	1.7	*	*	0.0
Coriander seeds	0.6	*	*	0.1	*
Livestock	-	-	-	-	-
Bone	20.6	19.9	28.6	18.3	13.4

Source: The Study Team partially revised statistics published in Karachi by the National Bureau of Statistics.

Note: * indicates less than 50 tons exported.

Table 2-23: Trend in Agricultural Exports on a Monetary Basis

(Unit: 1 million rupees)

FY Name of Agricultural Product	1998-99	1999-00	2000-01	2001-02	2002-03
Major Agricultural Products					
Cotton	135.5	3,792.0	8,930.1	1,551.4	2,872.6
Cotton waste	1,249.4	1,729.8	2,377.5	2,258.0	2,110.6
Raw wool	178.2	110.2	78.5	83.4	133.0
Fish	6,174.9	7,190.7	7,994.5	7,745.8	7,868.5
Rice (Total)	26,825.0	27,944.4	30,849.3	27,509.5	32,432.8
Basmati rice	14,224.1	15,037.6	13,831.4	15,856.4	21,077.2
Other rice	12,600.9	12,906.7	17,017.9	11,653.1	11,355.6
Fruits	2,772.8	4,129.5	4,575.0	5,083.5	4,864.5
Honey	72.9	82.6	55.0	53.0	96.0
Vegetables (excluding 1 & 2)	268.8	468.3	357.4	502.7	787.8
Potatoes (1)	843.9	503.8	389.3	373.6	398.5
Onions (2)	1,200.1	1,028.7	601.3	332.9	355.7
Peppers	67.2	114.8	179.5	101.6	203.2

FY Name of Agricultural Product	1998-99	1999-00	2000-01	2001-02	2002-03
Other varieties	-	-	457.7	454.0	382.4
Castor oil	24.9	24.9	0.3	36.6	19.2
Cumin, caraway seed	34.9	229.5	34.0	40.4	45.3
Poppy seeds	252.7	60.8	0.3	0.1	0.0
Coriander seeds	3.8	1.1	2.7	8.0	3.0
Livestock	150.6	81.4	292.3	420.8	1,278.9
Bone	216.5	183.4	300.0	218.9	153.4
Total	**40,472.1**	**47,675.9**	**57,474.7**	**46,774.2**	**54,005.4**

Section 2.4: Use of Bulldozers to Construct Water and Land Holding Facilities

The hill tract[6] region running through Balochistan Province, the NWFP, and southwestern Punjab Province lies in an arid to semi-arid region where yearly rainfall is scarce (see Chart 1: Pakistan's Climatic Regions and Annual Rainfall). Since flowing rivers are rare in most years, they must rely on the run-off from seasonal rivers (temporary rivers[7]) which flow only during the monsoon season, groundwater, and rainfall for water sources. This water is used for drinking water and for irrigation; preventing rainwater run-off has become a serious issue for both the provincial government and the farmers, in order to secure water supplies.

The provincial governments do have plans to construct check dams (dams to collect groundwater) and small-scale dams; however, budgetary issues stand in the way of progress on these projects.

Additionally, farmers are building embankments of earth and stone along with water reservoirs when they prepare agricultural lands, in order to conserve water and soil. Bulldozers are essential for this type of work. According to records of actual usage for Balochistan Province, 30 percent of the total usage time is spent on the construction of water reservoirs and mini dams. Bulldozers also play an essential role in securing water supplies for the crops and everyday needs of the farmers.

Section 2.5: Actions of Other Donors

As for as other donors in this sector, the Chinese government is apparently intending to providing aid. They will provide 50 million yuan (¥665 million, assuming $1 = ¥110 = 8.27 yuan) and 50 bulldozers. The recipient was first designated as Sindh Province; however, they now intend to distribute 25 bulldozers each to both Balochistan Province and the NWFP.

According to NWFP representatives, Chinese government agents will be visiting in August or September 2004 to determine the means, etc.

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[6]These are temporary rivers in arid regions, when a sudden onrush of water immediately follows a heavy rain. There are only a few days a year when this happens, although this depends on regional conditions.

[7]Rivers immediately resulting from rainfall; one type of such rivers.

However, Balochistan Province has some doubt as to the quality of Chinese-made bulldozers; they have submitted a request to the federal government to first receive two bulldozers for trial use, and then, based on the results of those trials, receive the rest of the donated machines.

Section 2.6: Prioritizing the Repair Facilities of Each Province According to the Area of Land to be Developed

As we have noted, each province has not specifically designated which regions will be developed as agricultural land. They are planning agricultural land development based on the initiative of farmers to develop land and on the number of operable bulldozers available. In the chart below, we have prioritized repair facilities according to demand. We have forecasted bulldozer demand (the percentage of land under jurisdiction which will see an increase in the frequency of use for bulldozers) based on those lands that could be candidates for scheduled development, provided that there is progress seen in the development plans for unused cultivable land owned by farming households in each province and for water resource development projects.

Chart 2-24: Prioritization of Repair Facilities by the Area of Land Likely to Be Developed

Rank	Punjab Province	Sindh Province	Balochistan Province	North-West Frontier Province
1	Multan	Tando Jam	Quetta	D.I.Khan
2	Faisalabad	Sukkur	Turbat	Peshawar
3	Talagang	Khairpur	Khuzdar	
4	Lahore			
5	Bahawalpur			

CHAPTER III: EQUIPMENT SUPPLIED THROUGH AID FROM JAPAN AND THE CURRENT STATUS OF THE AGRICULTURAL EQUIPMENT REPAIR FACILITIES

1. In general, the donated equipment (bulldozers) has been used past what is considered its useful economic life in Japan; however, technical, management, preservation, and quality control skills will now be needed to prolong the life of these bulldozers.
2. The agricultural machinery repair facilities are for the maintenance and repair of many different kinds of agricultural equipment; there is a lack of sufficient machinery and equipment required to maintain these bulldozers.
3. The supply of technical cooperation together with the donation of machinery is essential, since basic technical skills and know-how for maintaining the bulldozers is lacking.

Section 3.1: Equipment Procured Through Aid from Japan (Bulldozers)

From 1978 to 1994, the Japanese government has assisted with the procurement of 1,580 bulldozers by the Agricultural Departments of each province. These were provided to assist Pakistan in agricultural development and were supplied through grant aid and through 2KR cooperation.

Table 3-1 below shows the number of units supplied and the province to which they were supplied each fiscal year. Table 3-2 also shows the number of units supplied by province.

Table 3-1: Number of Bulldozers Supplied Each Fiscal Year

Fiscal Year	Recipient	# of Units Supplied (By Maker)		Programs Providing Cooperation
		Komatsu	Caterpillar-Mitsubishi	
1978-79	Punjab Province	397		Unable to confirm
1981-82	Sindh Province	85		"
1982-83	Sindh Province	25		"
1982	NWFP	19		"
1982-83	Balochistan Province		115	"
1985-86	Punjab Province	106		2KR
1986-87	Punjab Province	44		2KR
1987-88	Balochistan Province		86	2KR
1986-87	Punjab Province		150	2KR
1987	NWFP	36+36*		2KR
1988-89	Punjab Province		140	2KR
1990-91	Sindh Province	17		2KR
1991-92	Sindh Province	91		2KR
1991-92	Balochistan Province		10	2KR
1991-92	Sindh Province		30	2KR
1992-93	Punjab Province	71		Unclear
1992-93	Punjab Province		42	Unclear
1994	Balochistan Province		80	Grant Aid?
	Subtotal:	927	653	
	Total:	1580		

Source: Feasibility Report on Land & Water Resource Development Plans to Reduce Poverty; March 2002

Note: The years indicate the years in which the equipment supply business was contracted out. The asterisk (*) indicates that the machinery types differed, but 36 units were supplied.

Table 3-2: Number of Bulldozers Supplied by Province

Province	Total Number of Units Supplied		
	Komatsu	Caterpillar-Mitsubishi	Total
Punjab Province	618	332	950
Sindh Province	218	30	248
NWFP	91	0	91
Balochistan Province		291	291
Total:	891	689	1,580

Source: Feasibility Report on Land & Water Resource Development Plans to Reduce Poverty; March 2002

Subsection 3.1.1: Number of Bulldozers Owned by Each Province and Utilization Rates

The number of bulldozers currently under the jurisdiction of the repair facilities subject to the study in each province and the operating status of said bulldozers are as noted below.

With the exception of Punjab Province, we were unable to obtain data indicating the number of operable machines by type of equipment. Although daily data on the

operating status of the bulldozers and where they are located have been recorded in logs (on paper), this information is rarely organized consistently. The head office does have a computer and they are starting to organize these data; however, this process has just begun, and it appeared that they lacked personnel with sufficient computer skills for putting the data in order.

Although the system of computerized management in Punjab Province is good compared to that of the other provinces, it is still insufficient.

1) Punjab Province

The Agricultural Machinery Division of the Punjab Agricultural Department currently possesses 551 bulldozers. Of these, 491 are kept in the Machinery Division of the Agricultural Department; the remaining 60 units are kept in the Soil Conservation Division. This study addresses the 491 units assigned to the Agricultural Machinery Division.

This province has repair facilities in a total of 24 locations, classified into categories A, B, and C. Repair facilities at five of the Category A locations are subject to improvements under the recent requests. The locations of the repair facilities subject to this study are shown on the map of requested repair facilities.

Table 3-3: Number of Repair Facilities in Punjab Province by Category

Category	#	Repair Facility	Categorical Breakdown
A	8	1. Bahawalpur 2. Multan 3. Faisalabad 4. Lahore 5. Quaidabad 6. Layyah 7. Rawalpindi 8. Talagan	Machinery, welding, electric, fuel injection pumps, automotive ,bulldozer engines, vehicle bodies, carpentry, casting, metalworking/forging, assembly
B	7	1. D.I. Khan 2. Ssahiwal 3. Gujranwala 4. Mianwali 5. Attock 6. Khanpur 7. Rawalpindi (Soil Conservation Div.)	Machinery, welding, electric, automotive, bulldozer engines, casting, metalworking, forging, assembly
C	9	1. Bahawalnagar 2. Vehari 3. Kasur 4. Sheikhupura 5. Sailkot 6. Gujrat 7. Sargodha 8. Jhelum 9. Jhang	Machinery, welding, metalworking, assembly
Total:	24		

The status of the bulldozers under the jurisdiction of these facilities is shown in the table below.

Table 3-4: Bulldozers under the Jurisdiction of Repair Facilities in Punjab Province Subject to This Study

Repair Facility		Komatsu D50		Caterpillar D4H		Units Owned	Operable Units
		Units Owned	Operable Units	Units Owned	Operable Units		
1.	Bahawalpur	67	44	23	4	90	48
2.	Multan	103	71	58	17	161	90
3.	Faisalabad	33	29	51	21	120	50
4.	Talagang	36	30	0	0	56	30
5.	Lahore	26	50	38	17	64	67
	Total:	**321**	**224**	**170**	**61**	**491**	**285**
Utilization Rate (%)		**Approx. 70%**		**Approx. 35%**		**Approx. 58%**	

Note: The number of operable units was determined in March 2003. (The number of operable units is calculated from the number of units and the operating time of the bulldozers in Table 3-15; this differs by year.)

2) Sindh Province

There are currently 199 bulldozers stationed in Sindh province.

In total, there are 17 repair facilities in the province: 5 main repair facilities, 10 subsidiary repair facilities and 2 unit repair facilities. Three of the main repair facilities will have improvements made under the current request. The locations of the repair facilities subject to this study are shown on the map of requested repair facilities.

Table 3-5: Number of Repair Facilities in Sindh Province and the Types of Repairs Undertaken

Repair Facility Type	#	Repair Facility		Types of Repairs Made
Main Repair Facilities	5	1. Sukkur 3. Larkan 5. Thatta	2. Tandojam 4. Khairpur	Can handle comparatively large-scale repairs and equipment
Subsidiary Repair Facilities	10	1. Ghotki 3. Saikarpur 5. Sanghar 7. Nawabshah 9. Hyderabad (Nareja)	2. Jacobabad (Kandhkot) 4. Mirpurkhas 6. Dadu 8. Badin 10. Karachi	Daily inspections and light repairs
Unit Facilities	2	1. Sehwan	2. Nausharo-Feroz (Moro)	Daily inspections and light repairs
Total:	**17**			

The status of the bulldozers under the jurisdiction of these facilities is shown in the table below.

Table 3-6: Bulldozers under the Jurisdiction of Repair Facilities in Sindh Province Subject to This Study

Repair Facility		Caterpillar D4H		Komatsu D50		KSR		Total	
		Units Owned	Operable Units	Units Owned	Operable Units	Units Owned	Operable Units	Units Owned	Operable Units
1.	Tandojam	20	N.A.	58	N.A.	1	N.A.	83	36
2.	Khairpur	1	N.A.	22	N.A.	0	N.A.	23	13
3.	Sukkur	4	N.A.	25	N.A.	4	N.A.	29	15
	Total:	**25**		**105**	**67**	**5**		**135**	**64**
Utilization Rate (%)								**Approx. 47%**	

3) Balochistan Province

The Agricultural Department for Balochistan Province currently possesses 499 bulldozers. Three of the repair facilities will have improvements made under the current requests. The status of the bulldozers under the jurisdiction of these facilities is shown in the table below. The locations of the repair facilities subject to this study are shown on the map of requested repair facilities.

Table 3-7: Bulldozers under the Jurisdiction of Repair Facilities in Balochistan Province Subject to This Study

Repair Facility		Caterpillar D6D		Caterpillar D5H		Komatsu D65E		Other		Total	
		Units Owned	Operable Units	Units Owned	Operable Units	Units Owned	Operable Units	Units Owned	Operable Units	Units Owned	Operable Units
1.	Quetta	108		51		12		6		177	105
2.	Khuzdar	51		20		11				82	54
3.	Turbat	39		13		4				56	25
	Total:	**198**		**84**		**27**		**6**		**315**	**184**
Utilization Rate (%)										**Approx. 57%**	

Note: The number of operable units by machine type is unknown.

4) North-West Frontier Province (NWFP)

The Agricultural Department for the NWFP currently possesses 25 bulldozers. All of the 91 bulldozers provided by the Japanese government have been abandoned as inoperable.

Two of the repair facilities in the NWFP will have improvements made under the current requests. The status of the bulldozers under the jurisdiction of these facilities is shown in the table below.

The locations of the repair facilities subject to this study are shown on the map of requested repair facilities.

Table 3-8: Bulldozers under the Jurisdiction of Repair Facilities in the NWFP Subject to This Study

Repair Facility		Komatsu		John Deere (USA)		Total	
		Units Owned	Operable Units	Units Owned	Operable Units	Units Owned	Operable Units
1.	Tarnab	0	0	25	10	25	10
2.	D.I. Khan	N.A.	0				
	Total:	**0**	**0**	**25**	**10**	**25**	**10**
Utilization Rate (%)		**0%**		**40%**		**40%**	

As we state in Chapter 4, jurisdiction of the bulldozers for the NWFP was handed over to the districts in FY2001-2002, due to regional devolution. At the time, the provincial government owned 114 bulldozers; 100 of these were operable and 75 of the 100 were distributed to 19 districts. The table above addresses only the 25 bulldozers still owned by the provincial government.

Subsection 3.1.2: Operating Status of Equipment (Bulldozers) Procured Through Japanese Aid

The following factors affect the useful life of a bulldozer:

(1) Land quality and terrain
(2) Skill levels of equipment operators
(3) Ongoing monitoring of equipment

1) Land Quality and Terrain

In Japan, bulldozers are primarily used for construction work; however, almost all of the bulldozers the Agricultural Departments rent out are used for reclamation of agricultural land. By and large, the land is flat, with soil that is sandy with clay mixed in. Most of the work involves removing stones the size of a man's head. The burden on the machines is relatively small compared to that when used in Japan and we did not see any signs of unreasonable use.

The table below shows the purpose of use for bulldozers in each province over the past five years.

Table 3-9: Purposes for Which Bulldozers are Used

Fiscal Year	Reason Used	Time Used as a Percentage of Total Operating Hours			
		Punjab Province	Sindh Province*	Balochistan Province	NWFP
July 1999 to June 2000	Preparation of Regions Using Irrigation Canals[1]	35	39	10	N.A.
	Preparation of Rain-Fed Region	16	-	40	N.A.
	Preparation of Regions Using Rainfall for Irrigation	4	1	5	N.A.
	Reclamation of Unused Cultivable Land	43	60	10	N.A.
	Removal of Salinified Soil	1	-	5	N.A.
	Construction of Mini Dams[2] or Reservoirs[3]	1	-	30	N.A.
	Other	-	-	-	N.A.
July 2000 to June 2001	Preparation of Regions Using Irrigation Canals	37	35	10	N.A.
	Preparation of Rain-Fed Region	18		40	N.A.
	Preparation of Regions Using Rainfall for Irrigation	2	2	5	N.A.
	Reclamation of Unused Cultivable Land	42	63	10	N.A.
	Removal of Salinified Soil	1	-	5	N.A.
	Construction of Mini Dams or Reservoirs	-	-	30	N.A.
	Other	-	-	-	N.A.
July 2001 to June 2002	Preparation of Regions Using Irrigation Canals	17	48	10	N.A.
	Preparation of Rain-Fed Region	1		40	N.A.
	Preparation of Regions Using Rainfall for Irrigation	48	1	5	N.A.
	Reclamation of Unused Cultivable Land	1	51	10	N.A.
	Removal of Salinified Soil	1	-	5	N.A.
	Construction of Mini Dams or Reservoirs	-	-	30	N.A.
	Other	-	-	-	N.A.

[1]Regions irrigated by water canals: Regions that are irrigated by extracting water from irrigation canals.
[2]Mini dams: Small dams that irrigate 9 to 10 ha and have water reserves of 27,450 to 30,500 m^3. Constructed with bulldozers rented by individual farmers; the Agricultural Departments provide technical advice.
[3]Reservoirs: Small ponds that irrigate 4 to 6 ha and have water reserves of 12,200 to 18,300 m^3. Constructed with bulldozers rented by individual farmers; the Agricultural Departments provide technical advice.

Fiscal Year	Reason Used	Time Used as a Percentage of Total Operating Hours			
		Punjab Province	Sindh Province*	Balochistan Province	NWFP
July 2002 to June 2003	Preparation of Regions Using Irrigation Canals	34	52	10	N.A.
	Preparation of Rain-Fed Region	20	-	40	N.A.
	Preparation of Regions Using Rainfall for Irrigation	1	1	5	N.A.
	Reclamation of Unused Cultivable Land	42	47	10	N.A.
	Removal of Salinified Soil	1	-	5	N.A.
	Construction of Mini Dams or Reservoirs	2	-	30	N.A.
	Other	-	-	-	N.A.
July 2003 to June 2004	Preparation of Regions Using Irrigation Canals	33	51	10	N.A.
	Preparation of Rain-Fed Region	18	-	40	N.A.
	Preparation of Regions Using Rainfall for Irrigation	2	-	5	N.A.
	Reclamation of Unused Cultivable Land	46	49	10	N.A.
	Removal of Salinified Soil	1	-	5	N.A.
	Construction of Mini Dams or Reservoirs	-	-	30	N.A.
	Other	-	-	-	N.A.

Note: This indicates the percentage of land for Sindh Province.

2) Skill Levels of Equipment Operators

When bulldozers are rented, an operator and assistant are dispatched together with the bulldozer to operate it.

The skills for operating the bulldozers are sound; however, the daily checks conducted in Japan before and after using the machine are not conducted. We were unable to confirm the existence of daily checkpoint lists for the bulldozers we surveyed during our study. Despite this, there is a great need to add such checks as a daily task essential to proper use, since conducting these checks enable repairs to be made while the damage is still minimal; this will result in a longer lifespan for the bulldozers. Specifically, technical training is essential for operators and assistants on initial checks, quality monitoring, methods of diagnosing the early stages of breakdown, and what steps to take when abnormalities are discovered.

Subsection 3.1.3: Status of Ongoing Management of Equipment (Bulldozers) Provided Through Japanese Aid

The methods for monitoring equipment can be broadly classified into the following three categories:

(1) Maintenance skills
(2) Daily checks
(3) Quality control

1) Maintenance Skills

There is ample room for improvement in the maintenance skills of the repair facilities. We witnessed improper maintenance and repairs, such as poor cleaning or incomplete welding, and the use of cheap, unauthorized parts and lubricants; these practices accelerate bulldozer deterioration. Verifying operating performance (quality control) following repairs is also problematic, since the repair facilities are not equipped with measuring instruments or testing devices.

Furthermore, bulldozer manufacturers have established protocols for maintenance checks in Japan, as well as restrictive conditions such as not offering free repairs or recalls if the user has failed to follow these protocols; these protocols and restrictive conditions are absent in Pakistan, making it easy to use cheap parts or improper maintenance methods.

2) Daily Checks

Major checks, such as initial checks, CTS Check Reports (Customer Track Service)[4], and preventive maintenance, are rarely conducted. Consequently, there is a tendency to perform similar repairs on a given bulldozer more than is necessary. Daily checks to determine the cause of a problem and take immediate steps to address it are effective in reducing machine downtime[5].

3) Quality Control

The basics of quality control involve keeping and utilizing maintenance records and operation logs. Although this type of data is recorded quite scrupulously in each repair facility, it is not organized in a manner that enables it to be used in subsequent maintenance and repairs. As a result, activities such as analysis and breakdown of the data that would lead to the prevention of reoccurring problems, useful life extension, and cost reduction are not being performed. Moreover, quality control measures (QC)[6] that would serve to monitor set standards of quality and

[4]CTS (Customer Track Service): Suspension parts are checked and accurately measured for signs of wear with high-tech measuring devices; based on this, proposals for the timing of repairs and repair methods are suggested to the customer.
[5]Machine downtime refers to the time during which a machine is inoperable due to breakdown.
[6]Quality control measures: This refers to activities that will please customers and increase the level of trust customers have by re-evaluating how work has been performed in the past, improving the quality of work,

provide measures for improving quality are not being implemented, despite the fact that this is simply a matter of common sense in Japan.

Section 3.2: Current Status of Bulldozer Repairs by the Agricultural Machinery Repair Facilities

The repair facilities subject to the current requests perform repairs on drill presses, other agricultural equipment, and automobiles in addition to bulldozers (bulldozers are classified as agricultural equipment for the purposes of this study), although there are differences in the degree to which this is being done among the repair facilities. As a result, the repair facilities are equipped with general-purpose machine tools in addition to the specialized equipment and machinery essential for repairing only bulldozers. In the course of this study, we reconfirmed that the current requests are specifically directed toward the effective use and maintenance of bulldozers. We primarily studied the current conditions of the repair facilities in relation to the repair and maintenance of bulldozers, since private repair facilities provide similar services for repairing other agricultural machinery and automobiles. The current status of each repair facility subject to this study with respect to the equipment and machinery used to maintain bulldozers is noted below. Since bulldozer repairs can be broadly classified into those dealing with the engine, the transmission, and the suspension, we organized the data in this manner. Furthermore, with respect to the level of facility management, we separated the welding and machining divisions, and conducted a comprehensive comparison and evaluation of budget management, personnel allocation, preservation and maintenance management, inventory management, operating management, creation of schedules for the operating process, and degree of technical skills.

Details on the bulldozer repair equipment owned by the repair facilities in each province, along with descriptions of their intended uses, are outlined in Appendices 2, 3, and 4.

1) Punjab Province

Table 3-10: Bulldozer Repair Equipment Owned by the Repair Facilities in Punjab Province

Types of Machines & Tools	Repair Facilities Subject to This Study				
	Bahawalpur	Multan	Faisalabad	Talagag	Lahore
Level of Management by Repair Facility: Technical Level of Management & Staff	Welding: High Machining: High	Welding: High Machining: High	Welding: High Machining: Med.	Welding: Med. Machining: Med.	Welding: Med. Machining: Med.
Equipment for Engines					
1. Pressure washer	×	×	×	×	×
2. Dynamometer	×	×	×	×	×
3. Valve grinder	○	○	○	○	○
4. Honing machine	×	×	×	○	

doing away with waste and inconsistency and, consequently, performing good work. QC is an abbreviation of quality control. It refers to improving the workplace by effectively cycling through the monitoring cycle of Planning work (P), Doing the work (D), Checking the Work (C), and Acting or taking proper measures (A).

Types of Machines & Tools	Repair Facilities Subject to This Study				
	Bahawalpur	Multan	Faisalabad	Talagag	Lahore
Level of Management by Repair Facility: Technical Level of Management & Staff	Welding: High Machining: High	Welding: High Machining: High	Welding: High Machining: Med.	Welding: Med. Machining: Med.	Welding: Med. Machining: Med.
5. Crankshaft grinder	○	○	○	○	○
6. Conrod boring/grinding machine	×	○	○	○	×
7. Piston grinder	×	×	×	○	×
8. Fuel emission tester	○	○	×	×	○
9. Specialized measuring equipment	×	×	×	×	×
Suspension-related & General Equipment					
1. MIG welding machine	×	○	×	○	×
2. Drill press	○	○	○	○	Y - poor condition
3. Lathe	○	○	○	○	○
4. Milling machine	×	○	×	○	○
5. Saw press	Y - poor condition	○	○	○	○
6. Track press	○	○	○	○	○
7. Crane	×	×	×	○	×
8. Hydraulic press	×	○	○	○	×
9. Shoe-bolt wrench	○	×	○	○	×

Note: "○" indicates possession of this function; "×" indicates absence of this function.
"High" means the level of operating management skills for the facility are high; "Med." means problems with operating management exist; "Low" means no operating management structure has been established.

2) Sindh Province

Table 3-11: Bulldozer Repair Equipment Owned by the Repair Facilities in Sindh Province

Component Name	Repair Facilities Subject to This Study		
	Hyderabad	Khairpur	Sikkur
Technical Level of Management & Staff	Machining: Low Welding: Med.	Impossible to Determine	Machining: Low Welding: Low
Equipment for Engines		It was impossible to actually go into the facility to survey it because the machinery warehouse (the old repair facility) was in danger of collapsing. Work on a new	
1. Pressure washer	×		×
2. Dynamometer	×		×
3. Valve Grinder	○		○
4. Honing Machine	○		○
5. Crankshaft grinder	○		Y - poor condition
6. Conrod boring/grinding machine	○		○
7. Piston grinder	×		○
8. Fuel emission tester	○		○
9. Specialized measuring equipment			

Component Name	Repair Facilities Subject to This Study		
	Hyderabad	Khairpur	Sikkur
Suspension-related & General Equipment		repair facility is currently underway. Construction is expected to reach completion in March 2005.	
1. MIG welding machine	×		×
2. Drill press	○		Y - poor condition
3. Lathe	○		○
4. Milling machine	○		○
5. Saw press	○		○
6. Track press	×		×
7. Crane	×		×
8. Hydraulic press	×		○
9. Shoe-bolt wrench	×		×

Note: "○" indicates possession of this function; "×" indicates absence of this function.
"High" means the level of operating management skills for the facility are high; "Med." means problems with operating management exist; "Low" means no operating management structure has been established.

3) Balochistan Province

Table 3-12: Bulldozer Repair Equipment Owned by the Repair Facilities in Balochistan Province

Component Name	Repair Facilities Subject to This Study		
	Quetta	Khuzdar	Turbat
Technical Level of Management & Staff	Machining: Med. Welding: Med.	Unclear	Machining: Low Welding: Low
Equipment for Engines		It was impossible to conduct the survey within the timeframe of the study due to political unrest. (The only available transportation to this facility is by land.)	No machine tools
1. Pressure washer	×		×
2. Dynamometer	×		×
3. Valve Grinder	○		×
4. Honing Machine	×		×
5. Crankshaft grinder	×		×
6. Conrod boring/grinding machine	○		×
7. Piston grinder	Y - some in poor condition		×
8. Fuel emission tester	○		×
9. Specialized measuring equipment	×		×
			×
Suspension-related & General Equipment			
1. MIG welding machine	×		×
2. Drill press	○		×
3. Lathe	○		×
4. Milling machine	○		×
5. Saw press	○		×
6. Track press	×		×
7. Crane	×		×

Component Name	Repair Facilities Subject to This Study		
	Quetta	Khuzdar	Turbat
Technical Level of Management & Staff	Machining: Med. Welding: Med.	Unclear	Machining: Low Welding: Low
8. Hydraulic press	○		×
9. Shoe-bolt wrench	×		×

Note: "○" indicates possession of this function; "×" indicates absence of this function.
"High" means the level of operating management skills for the facility are high; "Med." means problems with operating management exist; "Low" means no operating management structure has been established.

4) North-West Frontier Province (NWFP)

We conducted a site survey of the Tarnab repair facility; however, as we have stated in Chapter 4, Subsection 4.4.1, the bulldozers have been distributed to the districts. Since all repair equipment was distributed in conjunction with this, the repair facility is defunct.

Section 3.3: Status of Preservation and Maintenance of Equipment Used for Repairing Bulldozers at the Agricultural Machinery Repair Facilities

We found deficiencies in the preservation and maintenance of repair equipment (machinery and equipment) in all of the repair facilities studied. Machinery is not being fully utilized. Many of the machines had been abandoned when minor malfunctions occurred; without preservation and maintenance measures, many specialized tools and devices have been left unused for many years and consequently lost. We saw inoperable machinery everywhere. In particular, many of the abandoned machines and equipment were those donated by the former Soviet Union. This tendency was particularly conspicuous at the Faisalabad and Talagang repair facilities.

The current condition of existing machinery and equipment at each repair facility is noted in the table below.

Details on the machinery types and numbers of repair equipment for each repair facility are given in Appendix 2. However, a summary of each is given below.

Table 3-13: Maintenance Status of Machinery and Equipment at Repair Facilities Subject to This Study in Punjab Province

Repair Facility	Conditions	Machining Technology/ Plant Mgmt. Skills
Bahawalpur	・ 14 of the 23 machine tools were operable. All 8 lathes were operable. ・ 5 specialized machines for restoring bulldozers were operable. ・ This facility has a considerably high degree of technical capabilities in machining, such as fabrication of tapered screws (for water feed lines), crankshaft grinders, and roller shaft grinders. ・ It is also equipped with measuring equipment and test gauges; methods of usage are correct.	Mgmt.: High Machining: High Welding: High *Plant management skills are excellent.

Repair Facility	Conditions	Machining Technology/ Plant Mgmt. Skills
Multan	・ 24 of the 36 machine tools are operable. The facility is particularly well-equipped with lathes; superior technical skills were evident from the fact that they can manufacture parts that are usually procured (such as pin bushings). It is also equipped with a turret lathe, which requires technical know-how. ・ 9 out of 9 specialized machines for restoring bulldozers were operable. ・ It was also fully equipped with welding equipment for refurbishing rollers.	Mgmt.: High Machining: High Welding: High
Faisalabad	・ 17 out of 29 machine tools were operable. ・ 10 out of 10 specialized machines for restoring bulldozers were operable. It was equipped with machinery types that are used. ・ The lathes, turret lathes and slotters were of considerably high quality. ・ It was well-equipped with link presses and welding machines; however, they lack sufficient quantities of work to sustain current facility functions. ・ Much of the machinery from the former Soviet Union is lying unused as in Talagang, noted below.	Mgmt.: Med. Machining: Med. Welding: High
Talagang	・ 17 out of 54 machine tools are operable. ・ 8 out of 14 specialized machines for refurbishing bulldozers are operable. 12 machines from the former Soviet Union are unused and inoperable. ・ 40 years ago, in addition to bulldozers, they received machine tools for their ongoing maintenance from the former Soviet Union. However, these bulldozers were abandoned after 2,000 hours of operating time. Since then, there has not been enough work to operate the machines and they have been left unused. Japan supplied bulldozers, but with different machine specifications; they were unable to use the Soviet machinery and abandoned it. ・ A budget shortfall for maintaining the facilities is a problem. Budget for machinery & equipment maintenance expenses: For 2002: Rs 60,000 (¥120,000)/year For 2003: Rs 80,000 (¥160,000)/year Exchange rate as of June 2004: Rs 1.00 = ¥2	Mgmt.: Low Machining: Med. Welding: Med.
Lahore	・ 11 out of 28 machines are broken (including those being repaired). The remaining 17 machines are operable. ・ 6 out of 9 specialized machines for refurbishing bulldozers are operable. ・ As is the case with Faisalabad, there is a trend toward insufficient work.	Mgmt.: Med Machining: Med Welding: Med

Note: "High" means they are skilled in plant management. "Medium" means they are skilled in certain components of management. "Low" means there is insufficient infrastructure for plant management and operation.

Table 3-14: Maintenance Status of Machinery and Equipment at Repair Facilities Subject to This Study in Sindh Province

Repair Facility	Conditions	Machining Technology/ Plant Mgmt. Skills
Hyderabad	・ 36 out of 71 of the machinery/equipment owned have broken down. The remaining 35 units are operable for the most part. ・ Only one out of 22 specialized machines for refurbishing bulldozers is operable. ・ Welding technology is poor; however, they are making maximal use of inferior equipment and materials by employing rarely-used techniques (inserts). Technicians are eager for the introduction of welding technology.	Mgmt.: Low Machining: Low Welding: Medium
Khairpur	・ Part of the building had collapsed due to deterioration; we were unable to conduct a detailed survey because we could not enter the facility. ・ New premises are being built in a nearby location. This should be completed within 8 months. They intend to transfer 50 machines to the new facility, once completed. Bulldozer repair is currently being conducted in the field (outside). There is no factory space available at this time.	Unable to determine
Sukkur	・ 16 out of 42 general purpose machines/equipment have broken down. The remaining 26 are deemed operable in the data; many of these are in poor condition. Only 11 of these can be used properly. ・ 2 out of 9 specialized machines for refurbishing bulldozers are operable. ・ Since the chief engineer retired 10 years ago, the tools, measuring devices, and instruction manual have been lost for a German-made gear shaver (a gear-cutting machine with an estimated procurement price of ¥25 million; not included on the machinery list); it is currently lying unused. ・ They are now in the process of expanding the present repair facility to include a parts warehouse.	Mgmt.: Low Machining: Low Welding: Low The technical level is low; it is extremely likely that new machines will not be used after a few years even if they are procured.

Note: “High” means they are skilled in plant management. “Medium” means they are skilled in certain components of management. “Low” means there is insufficient infrastructure for plant management and operation.

Table 3-15: Maintenance Status of Machinery and Equipment at Repair Facilities Subject to This Study in Balochistan Province

Repair Facility	Conditions	Machining Technology/ Plant Mgmt. Skills
Quetta	・ 21 out of 35 machines are operable. 15 of these machines are currently in operation. ・ 12 out of 15 specialized machines for refurbishing bulldozers are operable. ・ The machine shop is relatively well-equipped. ・ In addition, there is 1 slotting machine that will be operable with minor repairs (not recorded in the log). ・ There is very little welding equipment, but there is ample space to perform welding operations in the shop.	Mgmt.: Med. Machining: Med. Welding: Low
Khuzdar	・ Not surveyed this time. ・ The log had 23 general purpose machines and 6 specialized machines for refurbishing bulldozers; however, judging from the pictures we obtained, there are 5-6 operable general-purpose machines (lathes, saw presses, drill presses, horizontal milling machines, etc.) and only 1 specialized machine for refurbishing bulldozers.	Unclear
Turbat	・ In 1993, an impressive repair facility was built in which it would be possible to install a ceiling crane. ・ There are almost no machines or equipment; only 1 saw press and 1 drill press. As a result, large-scale repairs such as engine analysis and repair and undercarriage replacement are handled through external, private businesses. (See Subsection 3.2.5, below, for the conditions at private facilities.)	Mgmt.: Low Machining: Low Welding: Low

Note: "High" means they are skilled in plant management. "Medium" means they are skilled in certain components of management. "Low" means there is insufficient infrastructure for plant management and operation.

Table 3-16: Maintenance Status of Machinery and Equipment at Repair Facilities Subject to This Study in the NWFP

Repair Facility	Conditions	Machining Technology/ Plant Mgmt. Skills
Tarnab	・ There is no repair facility. Bulldozer repairs are done outside.	Mgmt.: Low Machining: Low Welding: Low
D.I. Khan	・ We were unable to conduct a study at this time due to political unrest. ・ According to the engineer in charge at Tarnab, conditions at the D.I. Khan repair facility are similar to those at the Tarnab facility.	Mgmt.: Low Machining: Low Welding: Low

Note: "High" means they are skilled in plant management. "Medium" means they are skilled in certain components of management. "Low" means there is insufficient infrastructure for plant management and operation.

Table 3-17: Repair Facilities Other Than Those Run by the Machinery Divisions of the Provincial Agricultural Departments

Institution	Conditions at the Repair Facility	Machining Technology/ Plant Mgmt. Skills
Construction Machinery Training Institute (CMTI)	・ Some of the equipment was slightly old, but they are equipped with the latest technology and methods. ・ Superior to Japanese branch repair facilities; equipped with such things as a 10-ton crane (essential for moving heavy objects such as engines and suspension parts around the repair facility). ・ It also has fully equipped facilities for technical training and practice.	Mgmt.: High Machining: High Welding: High *This was the best equipped, best maintained and best managed facility we visited during this study.
Farm Machinery Training Institute (FMTI)	・ 6 out of 58 machines are broken down. The remaining 50 are operable. 2 machines are currently undergoing repairs. ・ 18 out of 19 specialized machines for refurbishing bulldozers are operable. ・ We received a clear explanation from them as to what machinery would be needed in the future (testing equipment, transport equipment, measuring equipment). Management has a firm grasp of current conditions.	Mgmt.: High Machining: High Welding: High *This repair facility is equipped with almost everything it needs.
Agricultural Mechanization Research Institute (AMRI)	・ This institution conducts research on, manufactures, and rents all types of agricultural equipment, such as harvesters. ・ Management and equipment is sufficient and they have a relatively good array of machines tools; 8 lathes and milling machines (such as Hitachi Seiki Milling Machines, etc.). However, they have minimal production and machining capabilities. ・ This facility is capable of manufacturing technically complex products; they have a heat treatment furnace and a durometer. ・ They conduct technical exchanges with the neighboring Multan workshop. ・ The budget is insufficient for procuring the requisite number of employees and educational materials.	Mgmt.: Med Machining: Med Welding: Med *The technical level is high, but machining skills are minimal. Research-oriented.

Note: "High" means they are skilled in plant management. "Medium" means they are skilled in certain components of management. "Low" means there is insufficient infrastructure for plant management and operation.

Section 3.4: The Level of Bulldozer Repair Technology in Pakistan

Subsection 3.4.1: Technical Skills of the Agricultural Machinery Repair Facility Staff

The technical skills of the repair facility staff vary widely from person to person. There are some excellent engineers who were educated in mechanical engineering at U.S. universities; however, there are also engineers without the most rudimentary

knowledge of machining. There are also many mechanics that actually make the repairs, yet do not understand the specialized terminology.

Given these conditions, we are doubtful that repair equipment (machine tools, measuring and testing equipment) can be fully utilized even if provided, given the current degree of technical skills and capabilities. In order to use this equipment effectively and efficiently, we believe that staff re-education and training is necessary. The agricultural departments in each province have neither a system for re-educating the staff that works at the repair facilities, nor an appropriate place to conduct the training. However, the Construction Machinery Training Institute (CMTI), which is under the jurisdiction of the Ministry of Telecommunications and was discussed above, runs short-term courses (3 to 5 months) on operating construction machinery (including bulldozers) and on mechanics. It has a track record of accepting research fellows whose responsibilities involve road construction at the Ministry of Telecommunications, from the Water and Power Resource Development Authority (WPDA), and from private construction companies. They also conduct seminars in Third World countries in cooperation with JICA. According to the President of CMTI, it would be feasible to accept research fellows from the Agricultural Department if the Agricultural Department were to request this. That said, the sense of hierarchy is extremely strong in Pakistan and it is difficult to envision an enterprise that would link the different ministries. To accomplish this, it would take strong external pressure from such organizations as the embassy and JICA.

Table 3-27 below gives a comparison of the functions and technical levels of each repair facility involved in the current requests.

Subsection 3.4.2: Technical Skills of Those Using Machinery (Machine Tools) and Those Operating the Machinery (Operators)

1) Management and Facility Engineers:

The machinery and equipment installed in the agricultural machinery repair facilities consist mainly of agricultural implements and general metalworking machines; these are also used for bulldozer repair. However, much of the machinery and equipment used for bulldozer repair has broken down or is in poor operating condition. While there are facilities with some specialized equipment for bulldozer repair, either all or parts of the functions have broken down, so these capabilities cannot be utilized.

Many of the repair facilities lack all or part of the machinery and equipment necessary for repairing bulldozers. In particular, since almost none have the washers, transport equipment (cranes, etc.), or manufactured components testing equipment indispensable to bulldozer repair, it is difficult to make high-quality repairs.

In addition to this, there is also a lack of measuring tools for normal work and hand tools for minor repairs; since the measuring devices for everyday work are stored in lockers, there is no indication that they are used on a regular basis. It is therefore difficult to determine the cause of breakdown in a machine tool or bulldozer, or to verify whether its functions have been recovered after repair.

It was also particularly evident that skills for maintaining a functioning repair facility (budgeting issues, personnel allocation, preservation and maintenance management, inventory management, work planning, process management, etc.) are at low levels due to inexperienced and insufficiently trained staff. The abandonment of high-priced machine tools without ever using them cannot be resolved merely by supplying machines (machine tools); there are a great deal of accumulated problems involving management and technical skills. Repair facility quality control issues are at the forefront; these need to be resolved as soon as possible.

2) Operators of Facility Machinery:

The technical capabilities for machining exist; however, assessing the resulting quality of work is difficult due to a lack of technical manuals and advisors. Some technical manuals are stored in the office lockers; however, the operators of the plant machinery cannot read and understand them because they are written in English.

Furthermore, welding technology is extremely poor overall. Secondary repairs to cracks at the site of failed welds frequently have to be made due to incomplete welds. The introduction to and instruction in the use of MIG welding machines (used for welding that requires fusing) is the most urgent task.

Subsection 3.4.3: The Current State of Machinery and Equipment for Repairing Bulldozers in Private Retail Shops and Repair Facilities

1) Local Dealers for Equipment (Bulldozers) Procured from Japan

The bulldozers provided by Japan are either manufactured by Komatsu or Caterpillar-Mitsubishi. The local dealers for each are noted below:

(1) Local Dealer for Komatsu-built Bulldozers:
Jaffer Brothers (Private) Ltd.

This is a trading company that handles large volumes of commercial products other than bulldozers, such as fertilizer. They are knowledgeable about bulldozers, but are not equipped with the large-scale machinery and equipment required for service. They would like to begin offering preventative maintenance (PM) and parts exchange services (PES[7]); however, they have not implemented these services due to a lack of customer demand. They carry an inventory of wearable parts valued at approximately ¥50 million and procure parts from Japan when necessary. It can take several months to procure parts for models that are more than ten years old.

[7]PES: A method of minimizing machine downtime (when machinery breaks down and is unusable for a period of time) by servicing parts and components in advance and immediately exchanging them when equipment breaks down.

(2) Local Dealer for Mitsubishi-Caterpillar Machines:
Allied Engineering & Services, Ltd.

The company's repair facility in Karachi is fully equipped for the refurbishment of bulldozers. Next to CMTI, it is the best repair facility. However, it provides service only for its own products.

Table 3-18: Comparison of the Servicing Capabilities of the Local Dealers for Komatsu and Caterpillar-Mitsubishi

Categories Compared	Jaffer Brothers (Komatsu Dealer)	Allied Engineering & Services (Caterpillar-Mitsubishi Dealer)
Equipment & capabilities	5 machines for engine testing. However, these are only for repairing equipment owned by the company itself.	Has virtually every machine needed.
Transport capabilities	Almost none	Has a large (10 ton) crane
PES	Not offered	Available
Use of remanufactured parts	Not offered	Not offered (given legal restrictions)
Value of parts inventory	Approximately ¥50 million	Approximately ¥200 million
Parts supply	Difficult for equipment manufactured more than 10 years ago.	No limits on parts supply

(3) Utilization of the Above Dealers by the Agricultural Departments of Each Province

The Machinery Divisions of the Provincial Agricultural Departments do not contract repairs out to dealers; rather, they handle bulldozer repairs themselves.

Furthermore, once the budget for procuring the necessary parts has been approved by the Agricultural Department, a public tender is published in the newspaper; businesses interested in bidding can do so. According to the chief engineer in the Agricultural Department, the manufacturers' dealers usually win the bid (the above dealers). He thought this was because they had the necessary channels to procure the cheapest price for the specifications.

2) Private Repair Facilities

(1) Private Auto Repair Center #1:
Saleer Engineering (in the city of Turbot)

This company has better equipment that Japan's local repair centers. They handle repairs for anything from bulldozers and trucks to motorcycle engines. They have the equipment for engine repair as well as the technical knowledge and skills to carry it out.

They use parts manufactured in Italy and China, which have no performance guarantees. Since authorized parts are expensive, they do not care to use them and do not procure parts from Japan.

They do not verify engine performance after repair; should a problem arise after reinstalling it in the vehicle, they do another overhaul. There are four repair facilities of similar size within a 100-km range. They also have three small shops.

(2) Private Auto Repair Center #2:
Within the Quetta city limits

This looked like an auto salvage yard and did not have sufficient space for making repairs. Bulldozer overhauls are unfeasible, but engine repairs are possible.

There is no other repair facility on the grounds of the main plant. However, it boasts the longest history in the city of Quetta and has the necessary equipment.

(3) Internal Repair Facilities for Private Construction Companies, #3:
Saita (Pakistan) Ltd. (the office is in Islamabad)

Saita (Pakistan) Ltd. is a construction company specializing in earthmoving, which requires heavy equipment. They hire their own mechanics for the repair of heavy equipment and perform these repairs onsite. Forty to 60 percent of the wearable parts purchased are procured from Karachi. Many of the wearable parts they purchase are manufactured in Pakistan, Italy, or China, and are 30 to 50 percent cheaper than Japanese products. Parts that are difficult to obtain domestically are imported from Singapore or Japan. It is considered more economical to obtain parts quickly via air shipments than to idle expensive heavy machinery. For the Cat D5 model, the wearable parts expense per hour for the company runs from ¥500 to ¥1,200. This is generally appropriate for the suspension and engine/hydraulics repairs that are usually necessary.

Section 3.5: Spare Parts Supply

The classifications of *spare parts*[8] and *wearable parts* for use in bulldozers are generally used interchangeably. While offices are requesting spare parts from other countries' governments, these parts are actually wearable parts, so we shall examine only wearable parts, for the sake of accuracy.

Subsection 3.5.1: Methods for Determining Which Machinery to Repair

Judging from useful economic life and the cost of overhauls, the machinery targeted for repairs will be those machines that have been in service for less than 20,000 hours. However, the precision of local overhauls conducted under conditions of insufficient funds and inspection/testing equipment cannot be considered as proper overhauls

[8]Spare parts are parts held in reserve for extraordinary circumstances such as disasters. A car's spare tire would be similar to this.

(naturally, there are no records of parts replacement when necessary, or measurements; so there is no performance verification data). We will, therefore, consider overhauls for bulldozers which have been in service over 20,000, but under 25,000 hours, this one time only. For the next round (if such an opportunity presents itself), we would like to target the repair of machines with up to two overhauls (having operating times of under 20,000 hours).

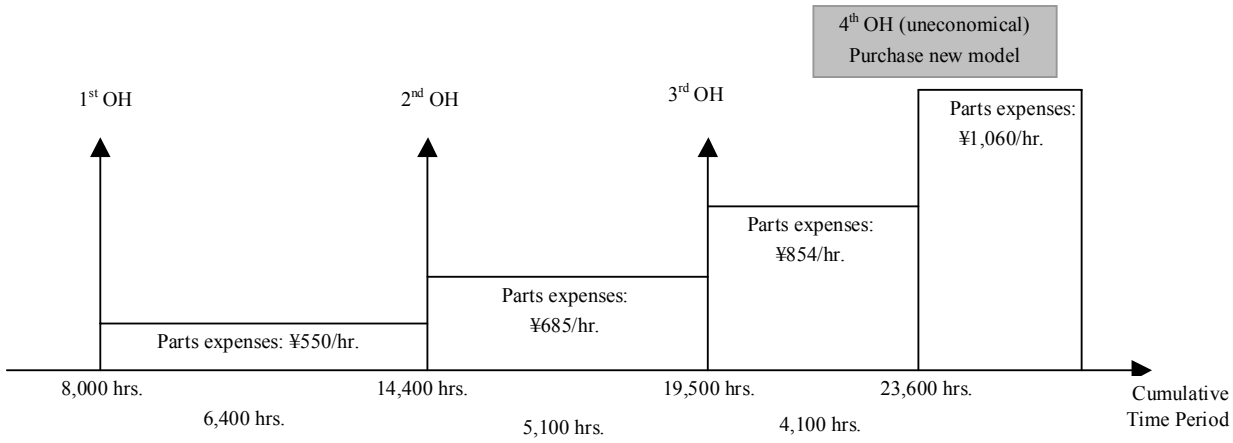
Since bulldozers that have incurred extensive damage in the past cannot be expected to recover their functions even after repair, these will be excluded from repairs. As the projections for remaining bulldozer life in Appendix 5 show, many machines have undergone three overhauls with less than 8,000 hours of operating time; they are not considered economical because their operating time is less than the cost of overhauls when compared to the non-operating time incurred within 15,000 hours of cumulative use.

1) Methods of Determining the Useful Economic Lifespan for Bulldozers

In Japan, bulldozers with a cumulative operating time of 8,000 to 10,000 hours are exchanged for new models (the actual cost for the D4 class up to this point is ¥8 million; the economic life of a new model). When a bulldozer is overhauled instead of opting for replacement with a new model, the horsepower decreases and wearable parts expenses increase substantially. For example, in Japan a bulldozer would have to undergo three overhauls to keep it running for 25,000 hours; the power of the bulldozer would decrease by 10 percent each time it was overhauled.

Based on this and in light of the service standards in Pakistan, to keep a bulldozer in operation for 25,000 hours would require 4 overhauls, as shown below. Each time the bulldozer is overhauled, there would be a 20 percent decrease in capacity.

In Japan, it generally costs around ¥3.5 million to overhaul a bulldozer one time. According to our oral survey of the local Caterpillar-Mitsubishi dealer, the cost of one overhaul runs about ¥4.0 million. However, we calculated overhaul (OH) expenses using the ¥3.5 million standard from Japan, after considering the accuracy of the calculations and the cost of parts locally.



Note: Parts expenses: actual average, Japan. Each overhaul costs ¥3.5 million.

Chart 3.1: Relationship between extending bulldozer operation and wearable parts expenses for overhauls

Below, we calculate the repair expenses per hour for purchasing a new model (assuming the ¥8 million actual purchase price up to this point), and taking steps (purchasing a new model or extending useful life through overhaul) when overhaul becomes necessary due to a large decrease in operating capacity.

Step	Step Taken	Expenses	Operating time Between Overhauls	Hours of extended operation	Expenses per hour (yen/hr)
1	Replace with new model	¥6.5 million (¥8 - 1.5 million)	8,000	8,000	¥6.5 million ÷ 8,000hrs = 812.5 ≒ 800
2	1st overhaul	¥3.5 million	8,000×0.8=6,400	6,400	¥3.5 million ÷ 6,400 hrs = 546.8 ≒ 550
3	2nd overhaul	¥3.5 million	6,400×0.8□5,100	5,100	¥3.5 million ÷ 5,100 hrs = 686.2 ≒ 685
4	3rd overhaul	¥3.5 million	5,100×0.8□4,100	4,100	¥3.5 million ÷ 4,100 hrs = 853.6 ≒ 854
5	4th overhaul	¥3.5 million	4,100×0.8□3,300		¥3.5 million ÷ 3,300 hrs = 1,060

As can be seen in the table above, four overhauls are generally necessary to keep bulldozers in operation for 25,000 hours, given the conditions in Pakistan.

If a bulldozer is exchanged for a new model, repair expenses will run ¥800/hour; repair expenses will run ¥1,060/hour at the time of the fourth overhaul. Consequently, repair expenses at the time of the fourth overhaul are higher than for purchasing a new model by ¥260/hour. Therefore, it is economical to use a bulldozer through the second overhaul and until just prior to the third overhaul, when repair expenses reach ¥854/hour versus the ¥800/hour for a new

machine. Although it is cheaper for Pakistan to purchase a new machine than to overhaul a bulldozer three times, it is difficult for the provincial Agricultural Departments to secure a budget large enough to purchase a new machine after repair expenses are factored in. For that reason, we project that they will continue to use older bulldozers, replacing parts as they go, even through this is less economical.

As noted above, the classification of bulldozers under jurisdiction of the repair facilities by cumulative time in operation is shown in the table below. The hours of operation are those from the end of March 2003.

As noted above, a bulldozer can be kept in operation for 25,000 hours with three overhauls. We have taken this and adjusted it for Pakistan's standards (performing four overhauls and keeping bulldozers in operation for 25,000 hours, with capacity decreasing by 20 percent with each overhaul), and have calculated parts expenses that approximate actual expenses more closely in the table below. In order to perform these calculations, we must incorporate detailed conditions such as technical factors; the method of calculating these costs differs by manufacturer, and this information is not made public. Thus we have used ¥3.5 million as the standard for one overhaul, based on the results of our oral survey of major bulldozer manufacturers.

Table 3-19: Bulldozer Operating Time and Number of Bulldozers for Each District of Punjab Province

(Unit: Units)

Repair Facility / District	Machine Type	Bulldozers Targeted for Repair					Excluded from Repair		Total # of Bulldozers Targeted for Repair
		Under 5,000	5,000 to 9,999	10,000 to 14,999	15,000 to 19,999	20,000 to 24,999	Decided from Repair Record	25,000 or Over	
1. Bahawalpur									
(1) Bahawalpur	D4(C)		2	1	1				4
	D5(C)								
	D50(K)				1	2		12	3
(2) Rahim Yar Khan	D4(C)			1	2				3
	D5(C)								
	D50(K)			1	2	6		14	9
(3) Bahawalnagor	D4(C)			4					4
	D5(C)								
	D50(K)			2	1	3		4	6
Total (# of units)			2	9	7	11		30	29
Operating Time Remaining (hrs.)			35,000	112,500	52,500	27,500			227,500
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.200			
Total Repairs (¥000)			23,555	97,087	49,980	33,000			203,622
2. Multan									

Repair Facility	Machine Type	Bulldozers Targeted for Repair					Excluded from Repair		Total # of Bulldozers Targeted for Repair
District		Under 5,000	5,000 to 9,999	10,000 to 14,999	15,000 to 19,999	20,000 to 24,999	Decided from Repair Record	25,000 or Over	
(4) Multan	D4(C)			7	1				8
	D5(C)								
	D50(K)				3	2		4	5
(5) Khanewal	D4(C)				1	1			2
	D5(C)								
	D50(K)				2	4		1	6
(6) Vehari	D4(C)				4			1	4
	D5(C)								
	D50(K)					4		3	4
(7) Sahiwal	D4(C)			1	2	2			5
	D5(C)								
	D50(K)					3		1	3
(8) Lodhran	D4(C)								
	D5(C)								
	D50(K)								
(9) Pakpattan	D4(C)								
	D5(C)								
	D50(K)								
(10) D.G. Khan	D4(C)			1					1
	D5(C)								
	D50(K)					3		5	3
(11) Muzaffargarh	D4(C)			1	1				2
	D5(C)								
	D50(K)				2	4		4	6
(12) Rajanpur	D4(C)			1	1				2
	D5(C)								
	D50(K)			1	3	5			9
(13) Layyan	D4(C)			2					2
	D5(C)								
	D50(K)			1	1	4		1	6
Total (# of units)				15	21	32		20	68
Operating Time Remaining (hrs.)				187,500	157,500	80,000			425,000
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.200			
Total Repairs (¥000)			0	161,812	149,940	96,000			407,752
3. Faisalabad									
(14) Faisalabad	D4(C)			4					4
	D5(C)								
	D50(K)				2			2	4
(15) Jhang	D4(C)			3	3				6

Repair Facility	Machine Type	Bulldozers Targeted for Repair					Excluded from Repair		Total # of Bulldozers Targeted for Repair
District		Under 5,000	5,000 to 9,999	10,000 to 14,999	15,000 to 19,999	20,000 to 24,999	Decided from Repair Record	25,000 or Over	
	D5(C)								
	D50(K)			1	2				3
(16) Toba Tek Singh	D4(C)								
	D5(C)								
	D50(K)				1	2			3
(17) Sargodha	D4(C)				2				2
	D5(C)								
	D50(K)				3	3			6
(18) Khushab	D4(C)			1	1				2
	D5(C)								
	D50(K)				5	2		2	7
(19) Bakkar	D4(C)		1						1
	D5(C)								
	D50(K)			1	1	5			7
(20) Mianwali	D4(C)		1		2				3
	D5(C)								
	D50(K)			2		3		2	5
Total (# of units)			2	13	22	15			52
Operating Time Remaining (hrs.)			35,000	162,500	165,000	37,500			400,000
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.200			
Total Repairs (¥000)			23,555	140,238	157,080	45,000			365,873
4. Lahore									
(21) Lahore	D4(C)			2	1	1			4
	D5(C)								
	D50(K)				2				2
(22) Sheikhupura	D4(C)			2	1				3
	D5(C)								
	D50(K)			1	1	1			3
(23) Kasur	D4(C)				6				6
	D5(C)								
	D50(K)			1	1				2
(24) Okara	D4(C)			1					1
	D5(C)								
	D50(K)			2					2
(25) Gujranwala	D4(C)			3					3
	D5(C)								
	D50(K)				1	1			2
(26) Hafizabad	D4(C)								
	D5(C)								

Repair Facility	Machine Type	Bulldozers Targeted for Repair					Excluded from Repair		Total # of Bulldozers Targeted for Repair
District		Under 5,000	5,000 to 9,999	10,000 to 14,999	15,000 to 19,999	20,000 to 24,999	Decided from Repair Record	25,000 or Over	
	D50(K)			3					3
(27) Mandi	D4(C)								
Bahauddin	D5(C)								
	D50(K)								
(28) Sialkot	D4(C)								
	D5(C)								
	D50(K)			2					2
(29) Gujrat	D4(C)								
	D5(C)								
	D50(K)			3	2				4
(30) Narowal	D4(C)								
	D5(C)								
	D50(K)			2					2
Total (# of units)				22	15	3			40
Operating Time Remaining (hrs.)			0	275,000	112,500	7,500			395,000
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.2			
Total Repairs (¥000)			0	237,325	107,100	9,000			353,425
5. Talagang									
(31) Chakwal	D4(C)								
	D5(C)								
	D50(K)			1	4	14		5	19
(32) Jhelum	D4(C)								
	D5(C)								
	D50(K)				5	8		2	13
(33) Attock	D4(C)								
	D5(C)								
	D50(K)				3	5	2	5	8
Total (# of units)				1	12	27	2	12	40
Operating Time Remaining (hrs.)				12,500	90,000	67,500			170,000
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.2			
Total (¥000)			0	10,787	85,680	81,000			177,467
Grand Total (# of units)									**229**
Total Repairs (¥000)									**1,526,500**

Table 3-20: Bulldozer Operating Time and Number of Bulldozers for Each District of Sindh Province

(Unit: Units)

Repair Facility	Machine Type	Bulldozers Targeted for Repair					Excluded from Repair		Total # of Bulldozers Targeted for Repair
		Under 5,000	5,000 to 9,999	10,000 to 14,999	15,000 to 19,999	20,000 to 24,999	Decided from Repair Record	25,000 or Over	
District									
1 Hyderabad									
(1) Hyderabad	D4(C)		2						2
	D5(C)		1						1
	D50(K)			9	13	5		1	27
(2) Sanghar	D4(C)								
	D5(C)								
	D50(K)								
(3) Mirpurkhas	D4(C)								
	D5(C)								
	D50(K)			4	1				5
Total (# of units)			3	13	14	5		1	35
Operating Time Remaining (hrs.)			52,500	162,500	105,000	12,500			332,500
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.2			
Total Repairs (¥000)			35,332	140,237	99,960	15,000			290,529
2 Khairpur									
(4) Khairpur	D4(C)								
	D5(C)								
	D50(K)			2	7	3			12
(5) Nawabshah	D4(C)								
	D5(C)								
	D50(K)			3					3
(6) Nosheroferoze	D4(C)								
	D5(C)								
	D50(K)								
Total (# of units)				5	7	3			15
Operating Time Remaining (hrs.)			0	62,500	52,500	7,500			122,500
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.2			
Total Repairs (¥000)			0	53,937	49,980	9,000			112,917
3 Sukkur									
(7) Sukkur	D4(C)								
	D5(C)								
	D50(K)			1	4	1	4	1	6

Repair Facility	Machine Type	Bulldozers Targeted for Repair					Excluded from Repair		Total # of Bulldozers Targeted for Repair
		Under 5,000	5,000 to 9,999	10,000 to 14,999	15,000 to 19,999	20,000 to 24,999	Decided from Repair Record	25,000 or Over	
District									
(8) Shikarpur	D4(C)								
	D5(C)								
	D50(K)			2	2				4
(9) Landkhot									
(10) Jacobabad	D4(C)								
	D5(C)						4		
	D50(K)								
(11) Ghotki	D4(C)								
	D5(C)								
	D50(K)			2	2				4
Total (# of units)				5	8	1	4	1	14
Operating Time Remaining (hrs.)				62,500	60,000	2,500			125,000
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.2			
Total Repairs (¥000)			0	53,937	57,120	3,000			114,057
Grand Total (# of units)									**64**
Total Repairs (¥000)									**517,100**

Table 3-21: Bulldozer Operating Time and Number of Bulldozers for Each District of Balochistan Province

(Unit: Units)

Repair Facility / District		Machine Type	Bulldozers Targeted for Repair					Excluded from Repair		Total # of Bulldozers Targeted for Repair
			Under 5,000	5,000 to 9,999	10,000 to 14,999	15,000 to 19,999	20,000 to 24,999	Decided from Repair Record	25,000 or Over	
1. Quetta										
(1)	Quetta	D6(C)				1			4	1
		D5(C)					1		1	1
		D65E(K)								
(2)	Pishin	D6(C)			3	6	3			12
		D5(C)		2	4					6
		D65E(K)								
(3)	Killaabdullah	D6(C)			3	1			1	4
		D5(C)		0	0			4		0
		D65E(K)								
(4)	Chaghi	D6(C)								
		D5(C)								
		D65E(K)								
(5)	Loralai	D6(C)		5	3	3				11
		D5(C)		0	0			5		0
		D65E(K)								
(6)	Barkhan	D6(C)		1	2		1			4
		D5(C)		0	0			4		0
		D65E(K)								
(7)	Musa Kheli	D6(C)		3						3
		D5(C)		0				3		
		D65E(K)								
(8)	Zhob	D6(C)		3	3	1	2		1	9
		D5(C)			0			4		0
		D65E(K)								
(9)	Killa Saifullah	D6(C)		1	2	5	2			10
		D5(C)		0	0			4		0
		D65E(K)								
(10)	Sibi	D6(C)		1	4	1	4		2	10
		D5(C)		0					1	0
		D65E(K)								
(11)	Ziarat	D6(C)			3	1	3			7
		D5(C)		0	0				2	0
		D50(K)								
(12)	Kholu	D6(C)		1	3		5			9
		D5(C)		0				1		0
		D65E(K)								
(13)	Dera Bugti	D6(C)		1	1	4	1			7
		D5(C)								

Repair Facility		Machine Type	Bulldozers Targeted for Repair					Excluded from Repair		Total # of Bulldozers Targeted for Repair
District			Under 5,000	5,000 to 9,999	10,000 to 14,999	15,000 to 19,999	20,000 to 24,999	Decided from Repair Record	25,000 or Over	
		D65E(K)								
(14)	Nasirabad	D6(C)								
		D5(C)								
		D65E(K)								
(15)	Jaffarabad	D6(C)								
		D5(C)								
		D65E(K)								
(16)	Jhal Magsi	D6(C)			2	5	1			8
		D5(C)								
		D65E(K)		2						2
(17)	Bolan (Kachhi)	D6(C)			2	3	3			8
		D5(C)		0				2		0
		D65E(K)		1						1
Total (# of units)				21	35	31	26	30	12	113
Operating Time Remaining (hrs.)				367,500	437,500	232,500	65,000			1,102,500
Repair Expenses (¥000/hr)				0.673	0.863	0.952	1.2			
Total Repairs (¥000)				247,327	377,562	221,340	78,000			924,230
2. Khuzdar										
(18)	Mastung	D6(C)			4	4	2		1	10
		D5(C)								
		D50(K)								
(19)	Kalat	D6(C)		6	1		3			10
		D5(C)		0	0			3		0
		D65E(K)								
(20)	Khuzdar	D6(C)		4	4	1	4		2	13
		D5(C)			5					5
		D65E(K)								
(21)	Awaran	D6(C)		2		4	1			7
		D5(C)		0	0			2		0
		D65E(K)								
(22)	Kharan	D6(C)		2	2	3	3			10
		D5(C)		3						3
		D50(K)								
(23)	Lasbela	D6(C)		1	2	4	2			9
		D5(C)		4	3	1				8
		D65E(K)								
Total (# of units)				22	21	17	15		3	75

Repair Facility / District	Machine Type	Bulldozers Targeted for Repair					Excluded from Repair		Total # of Bulldozers Targeted for Repair
		Under 5,000	5,000 to 9,999	10,000 to 14,999	15,000 to 19,999	20,000 to 24,999	Decided from Repair Record	25,000 or Over	
Operating Time Remaining (hrs.)			420,000	300,000	127,500	37,500			885,000
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.2			
Total Repairs (¥000)			282,660	258,900	121,380	45,000			707,940
3.Turbat									
(25) Turbat	D6(C)			7	4	5		6	16
	D5(C)		0				4		
	D65E(K)								
(26) Gawadar	D6(C)			3	4	1			8
	D5(C)	0	0				6		0
	D65E(K)								
(29) Panjgur	D6(C)		2	2	3	1		2	8
	D5(C)		0	0			5		0
	D65E(K)								
Total (# of units)		0	2	12	11	7		13	32
Operating Time Remaining (hrs.)			35,000	150,000	82,500	17,500			285,000
Repair Expenses (¥000/hr)			0.673	0.863	0.952	1.2			
Total Repairs (¥000)			23,555	129,450	78,540	21,000			252,545
Grand Total (# of units)									**220**
Total Repairs (¥000)									**1,884,715**

Subsection 3.5.2: Confirming the Details of the Requests

1) Machinery (Bulldozers) Targeted for Repair as Requested by the Government of Pakistan

According to the requests of the Pakistani government, the bulldozers targeted for repair are those listed in Subsection 3.1.1; namely, the 966 bulldozers noted in the table below are targeted for repairs.

Table 3-22: Number of Units for which Repair was Requested by the Pakistani Government

Province	# of Units
Punjab Province	491
Sindh Province	135
Balochistan Province	315
NWFP	25
Total:	966

The breakdowns of these are as noted above in Tables 3-4, 3-6, 3-7, and 3-8.

2) Examining the Suitability of the Equipment Targeted for Requested Repairs (Bulldozer Remaining Life and Workload)

Among the equipment targeted for repair there are machines which have exceeded their useful economic life of 25,000 hours by a large margin.

Of the 966 machines targeted for the requested repairs, 513 of them have under 25,000 hours of cumulative operating time; the average remaining useful life for these is 4.7 years.

As we stated in Chapter 2, Section 2.2, there is much developable land in Pakistan that has not yet been developed. Moreover, the demand for development cannot be expected to decrease since the development of agricultural land is one of the government's highest priority plans. A decrease in demand for bulldozers is, therefore, not expected.

We will show the area of developable land as estimated from the remaining useful life of the existing bulldozers. This area is less than that noted in Chapter 2, Subsection 2.2.1 for the agricultural land development plans (these being three- or five-year plans that calculated the area from the possible operable hours of bulldozers owned).

The difference in area is due to the fact that these plans were based on the expectation of aid that is still indefinite and on bulldozer use that clearly exceeds useful economic life.

Table 3-23: Remaining Useful Life and Developable Land Area

Province	Repair Facility	# Targeted for Repairs	Remaining Operable Time (hrs)	Preparable Area per Hour (ha/hr)*	Developable Land Area (ha)	Area Intended for Agricultural Development (ha)
1. Punjab						・ Development of unused cultivable land (3 years) ② Land that is borderline as agricultural land (3 years) ・ Development of eroded land (3 years)
	Baharawalpur	29	227,500	0.016	3,640	
	Multan	68	425,000	0.016	6,800	
	Faisalabad	52	400,000	0.016	6,400	
	Lahore	40	395,000	0.016	6,320	
	Talagang	40	170,000	0.016	2,720	
	Total:	229	1,617,500		**25,880**	**48,564**
2. Sindh						
	Hyderabad	35	332,500	0.088	29,260	
	Khairpur	15	122,500	0.088	10,780	
	Sukkur	14	125,000	0.088	11,000	Total for 10 years
	Total:	64	580,000		**51,040**	**412,790**
3. Balochistan						
	Quetta	113	1,102,500	0.061	67,253	
	Kuzdar	75	885,000	0.061	53,985	
	Turbat	32	285,000	0.061	17,385	Total for 10 years
	Total:	220	2,272,500		**138,623**	**153,950**
4. NWFP						
	Tarmab	N.A.	N.A.	N.A.	N.A.	
	D.I.Khan	N.A.	N.A.	N.A.	N.A.	

Note: *The Preparable Area per Hour was determined from the actual results of each province up to the present. Actual results may differ according to differences in terrain and land quality.

The difference between the existing land area targeted for development and the land area the province wishes to develop (412,790 × 4.6/10 ≒ 190,000) is large for Sindh Province, as can be seen in the table above. As we stated before, this is because the provinces are basing their plans on the donation of 222 new bulldozers from some donor; in particular, from Japan. Other provinces have created plans based on improving or maintaining existing bulldozer capacity with aid from Japan.

The need to secure operable bulldozers through repair is therefore high, judging from the future amount of work needed and the remaining life span of the bulldozers.

Subsection 3.5.3: Number of Bulldozers Targeted for Repairs

The table on the following page shows number of units available by machine type; this was determined by assuming that bulldozers with less than 25,000 hours of cumulative operating time will be targeted for repair as well as in consideration of the existing usage conditions. A total of 513 machines will be targeted for repair: 229 in Punjab Province, 64 in Sindh Province, and 220 in Balochistan Province. This amounts to 56 percent of the 943 machines requested.

Table 3-24: Estimate for Purchasing New Machines to Equivalent in Number to Those Targeted for Repair

Types of Machines Targeted for Repair	# of Units Targeted for Repair					New model unit price* (¥000/unit)
	Pjb	Shindh	Balot	NWFP	Total	
D4	72	2	0	0	74	7,970
D5	0	1	23	0	24	13,770
D6	0	0	194	0	194	17,370
D50	157	61	0	0	218	13,280
D65E	0	0	3	0	3	21,060
Total	229	64	220	0	513	

Note: Pjb. is an abbreviation for Punjab Province; Sindh, for Sindh Province; Baloch., for Balochistan Province; and NWFP, for the North-West Frontier Province.

* For the new model unit price we used 90 percent of the list price on page 696 of the August 2004 issue of *Construction Prices*. We selected machine models that were close to existing machines in rated output.

Subsection 3.5.4: Wearable Parts Supply

1) Funds Needed for Repair Parts (Wearable Parts)

An estimated ¥800 million per year will be needed to cover future expenses for repair parts (wearable parts) for the 513 bulldozers targeted for repairs, as shown in the table below. This was calculated from Tables 3-19, 3-20, and 3-21. Moreover, the average remaining useful life of these bulldozers is 4.7 years. The estimated total expense for wearable parts needed during that time period is ¥3.9 billion.

Requisite expenses for wearable parts are listed below for each repair facility.

The bulldozers in the Talagan facility are showing the most signs of wear.

Table 3-25: Remaining Useful Economic Life of Bulldozers and Wearable Parts Expenses by Repair Facility

Province	Repair Facility	Cumulative Operating Hours (hrs)	# of Bulldozers Targeted for Repairs	# of Years Remaining of Useful Economic Life	Requisite Parts Expenses Per Year (¥000)	Total Wearable Parts Expense for Remaining Useful Life (¥000)
Punjab						
	Bahawalpur	227,500	29	4.4	46,278	203,623
	Multan	425,000	68	3.5	116,501	407,753
	Faisalabad	400,000	52	4.3	85,087	365,873
	Talagan	170,000	40	2.4	73,945	177,468
	Lahore	395,000	40	5.5	647,259	353,425
Sindh						
	Hyderabad	332,500	35	5.3	54,817	290,530
	Khairpur	122,500	15	4.5	25,093	112,918
	Sakkur	125,000	14	5.0	22,812	114,058
Balochistan						
	Quetta	1,102,500	113	5.4	171,154	924,230
	Khuzdar	885,500	75	6.6	107,264	707,940
	Turbad	285,000	32	4.9	51,540	252,545
	Total:	**4,470,000**	**513**	**4.7**	**818,750**	**3,910,357**

Alternatively, relatively minimal expenses for wearable parts would be incurred for up to 8,000 hours of cumulative operating time if new models were purchased and standard maintenance performed.

The table below compares purchasing 513 new models to repairing the existing machines. The estimated purchase price of these is approximately ¥7.2 billion.

Table 3-26: Estimated Expense for Purchasing New Machines Equivalent in Number to Those Targeted for Repair

Machines Targeted for Repairs	# of Machines Targeted for Repairs					New model unit price* (¥000/unit)	Total (¥000)	Models from Construction Price List
	Pjb	Shindh	Balot	NWFP	Total			
D4	72	2	0	0	74	7,970	589,780	D4G(HST)
D5	0	1	23	0	24	13,770	330,480	D5M(DPS)
D6	0	0	194	0	194	17,370	3,369,780	D6M(P/S)
D50	157	61	0	0	218	13,280	2,895,040	D53A-18
D65E	0	0	3	0	3	21,060	63,180	D65-EX-15
Total:	229	64	220	0	513		**7,248,260**	

Note: Pjb. is an abbreviation for Punjab Province; Sindh, for Sindh Province; Baloch., for Balochistan Province; and NWFP, for the North-West Frontier Province.

* For the new model unit price we used 90 percent of the list price on page 696 of the August 2004 issue of *Construction Prices*. We selected machine models that were close to existing machines in rated output.

However, given a useful economic life of 25,000 hours and 1,800 hours* of operation per year:

25,000 hours ÷ 1,800 hours/year = 13.9 years (ca. 14 years)

This means that the machines have a useful economic life of 14 years. Accordingly, the amount to be depreciated over 4.7 years is:

¥7,248,260,000 × (1-0.1) (4.7/14) = ¥2,190,010,000 (ca. ¥2.1 billion)

Moreover, the operating time for over 4.7 years is 4.7 years × 1,800 hours/year = 8,460 hours—the time for the next overhaul. In Japan, this is when machines are replaced; however, there should not be large repair expenses up to this point.

This value is 50 percent of the requisite wearable parts expenses for the remaining useful economic life of the existing machines.

The wearable parts expenses incurred if an equivalent number of new machines were purchased would be half that of the wearable parts expenses required for the 513 bulldozers over their remaining useful lives.

Note: *Yearly operating time assumption

The data compiled during our field surveys in Pakistan include many bulldozers with yearly operating times in excess of 30,000 hours. These figures are not reliable, however, as the hour meters have been detached (hour meters are normally attached to the engine to record its operating time). In Japan, small D4 bulldozers are only used about 1,000 hours per year for ancillary work since there is little heavy construction work.

We have therefore made the following assumptions for operating time.

52 weeks/year × 5days/week × 8 hours/day × 0.85 (operating rate: taking pre- and post-operating checks and rest breaks into consideration) = 1,768, or approximately 1,800 hours/year.

2) Parts Breakdown (Wearable Parts and Parts for Repair)

The following are the main bulldozer parts (both wearable parts and parts for repair):

(1) Engine Parts

Part	Standard Domestic Retail Price
Engine block	¥1.7 million
Crankshaft	¥650,000
Liner	¥20,000
Piston	¥20,000
Piston ring	¥15,000
Connection rod	¥80,000
Gasket	¥5,000

(2) Suspension Parts

Part	Standard Domestic Retail Price
Tracking mechanisms	¥700,000
Linking unit	¥20,000
Roller	¥25,000

(3) Other Parts

Part	Standard Domestic Retail Price
Pump assembly	¥600,000
Steering clutch	¥200,000

The government of Pakistan could not indicate what specific parts were necessary in the course of this study. Bulldozers are made up of around 30,000 parts; it is difficult to specify which parts among those will be needed. During our field surveys we did confirm the existence of stocking shelves for spare parts, but saw no evidence of a management log for recording the entry and exit of inventory. Since it is difficult for Pakistan to specify parts under these conditions, we did not learn which parts were desired during this study.

Under these conditions, it would take an enormous amount of time to verify what parts were currently stocked and to conduct an analysis of what parts would be needed. Should we proceed with this, we would like for Pakistan to take the following steps prior to commencement of any full-scale study:

(1) Create and submit an inventory chart for repair parts (we saw a considerable number of hoarded parts that will never be used in the warehouses).
(2) Create a projected parts list based on the information from the above list (a list of parts needed from Japan and third-party countries).

3) Technical Skills Required for Utilization and Ongoing Supervision

The technical skill levels of each repair facility for utilizing and performing ongoing supervision of existing repair materials and equipment is noted in Table 3.21, which compares standard criteria for determining which repair facilities to focus on. Management capabilities are poor in many of the repair facilities. Moreover, they have insufficient knowledge of the machines used for repair and cannot effectively use them.

It is necessary that there be plant managers who have the management skills to operate the facilities and who can instruct mechanics on the proper use of the machines used for repair.

Section 3.6: Procuring Machines and Tools for Use in Repairs

There is a close and indivisible relationship between improving bulldozer performance and improving repair facility operations. If the repair facilities are well equipped, bulldozer performance will improve automatically.

For example, if a MIG welding machine is not used and a poor fusion weld is done, the welded section may separate and re-welding will be necessary. Similarly, if an engine is re-installed in a bulldozer without verifying engine performance after an overhaul, another overhaul may be necessary due to insufficient power. Improving the functioning of repair facilities and raising the quality of each repair facility will result in a decrease in such problems in bulldozers, and furthermore will translate into improved performance and extended economic lives for the bulldozers.

Subsection 3.6.1: Selecting Repair Facilities to Focus On

An evaluation of the status of each repair facility is shown in the table below. We have evaluated each facility on four points: amount of work and future potential, plant management skills, technical skills for machining, and technical skills for welding.

Table 3-27: Comparative Criteria for Determining Repair Facilities to Focus On

		Amount of Work & Future Potential	Plant Management Skills	Technical Skills for Machining	Technical Skills for Welding	Reasons for a "Low" Rating
1. Punjab Province						
	Bahawalpur	Low	High	High	Low	Almost no welding equipment
	Multan	High	High	High	High	
	Faisalabad	High	Medium	High	High	
	Talagang	Medium	Low	Low	Medium	Lack of basic knowledge for operating repair machinery; insufficient maintenance of repair machinery
	Lahore	Low	Medium	Medium	Medium	Insufficient mechanic training
2. Sindh Province						
	Tandojam	High	Low	Medium	High	Insufficient repair machinery maintenance
	Khairpur	Medium	Low	Low	Low	Unable to determine
	Sukkur	Low	Low	Low	Low	Poor repair machinery management (many machines have been lost); almost no welding equipment
3. Balochistan Province						
	Quetta	High	High	Medium	Low	Almost no welding equipment
	Turbad	Low	Low	Low	Low	Almost no machining or welding equipment

Standards for Judgment: "High" means that management and technical oversight are solid; "Medium" means that these are basically sound, but improvement is needed on some points.

In the course of the current study, it became clear that there are places where expensive equipment, such as that donated by the former Soviet Union, has been abandoned without ever having been used. Chief engineers are indispensable to the management of repair equipment.

In consideration of geographical location and future workloads, we believe that the repair facilities listed below are most deserving of our attention.

Eighty percent of bulldozer repair consists of engine and suspension-related repairs (in terms of frequency and importance). The repairs actually being performed during our field surveys were on engines and suspensions. We feel that it would be advantageous to strive to concentrate technology transfers on facilities that perform frequent repairs.

In particular, we focused on the plant management capabilities at Bahawalpur and Multan; and the quantity of work at Faisalabad and Quetta (the number of bulldozers).

1) Specialized Repair Facilities for Engine Overhauls

We believe that the repair facilities at Bahawalpur, Faisalabad, and Quetta would be appropriate choices for specialization in engine overhauls. The Bahawalpur repair facility has outstanding plant management skills; the repair facilities in Faisalabad and Quetta have superior machining technology.

Engines are small, light, and consist of discrete components; consequently, removal and transport are relatively easy. Moreover, it would be advantageous to concentrate support on these three facilities from the viewpoint of maintaining a sufficient workload. Providing transport trailers in conjunction with the aid will enable the repair of equipment transported from other repair facilities. If high-grade overhauls are performed with the latest equipment, this will extend engine life, decrease the number of overhauls needed (lengthening the time between overhauls), and lighten the workload. It will therefore be possible to overhaul all bulldozers at only a few designated repair facilities.

However, since Sindh Province has not been included in the above list, the full-scale study may determine the configuration of an intraprovince infrastructure for overhauls to be unfeasible. We believe it necessary to consider the establishment of a main repair facility in Sindh Province, since it is ranked second among Pakistan's provinces in terms of agricultural activity.

Province	Repair Facility	Notes
Punjab	Bahawalpur	2 hours to Multan by car
	Faisalabad	
Balochistan	Quetta	

2) Specialized Repair Facilities for Re-Welding (Suspensions)

The status of existing welding equipment utilization and technical skills in welding are important in determining which repair facilities will specialize in re-welding (suspensions). Since Balochistan Province covers such a wide area (roughly the same area as Japan), it is necessary to designate a supervising facility within the province. This affects the Quetta repair facility. Quetta currently has almost no welding equipment or technical capabilities. However, we believe it would be advantageous to strengthen its technical capabilities with respect to MIG welding, since it is the central facility for Balochistan Province.

Re-welding (suspension) involves heavy objects and incurs transport costs, but does not require a high degree of product quality control skill. Local personnel will be able to perform overhauls after one rigorous training course. However, it will be necessary to perform ultrasound diagnostics every few years (to facilitate the early discovery and repair of cracks in the body; that said, once cracks in the body

have been discovered, high-level welding skills will be necessary, so separate measures must be taken).

Province	Repair Facility
Punjab	Multan
	Faisalabad
Sindh	Tandojam
Balochistan	Quetta

Subsection 3.6.2: Confirming the Specific Details of the Requests

1) Equipment Requested by Talagang, Faisalabad, Multan, and Bahawalpur in Punjab Province

The requests of each repair facility are noted in the table below.

Table 3-28: Equipment Requested by Punjab Province Unit: million Rs/¥

No.	Types of Machinery & Equipment	Unit Volume (Sets)	Unit Price	Total Amount
(1)	Engine repair A. Engine analysis & repair B. Transmission C. Engine cooling apparatus	4	50 (100)	200 (400)
(2)	Hydraulic system repair & testing	4	10 (20)	40 (80)
(3)	Fuel system repair & testing	4	10 (20)	40 (80)
(4)	Electrical system repair & testing	4	2.5 (5)	10 (20)
(5)	Other	4	20 (40)	80 (160)
(6)	Equipment transport & handling	4	10 (20)	40 (80)
(7)	Transport trucks	4	1.5 (3)	6 (12)
	Total Amount			416 (832)

Note: Exchange rate as of June 2004: Rs 1.00 = ¥2

The following additional requests were made during the course of this study.

Table 3-29: Specific, Additional Machinery and Equipment Requested by Talagang, Faisalabad, and Bahawalpur

No.	Equipment	Faisarabad	Talagang	Bahawalpul
(1)	Testing equipment, all types	○	○	○
(2)	Heat treatment equipment			○
(3)	Handling equipment	○	○	○
(4)	MIG & gas welding machines/equipment	○	○	○
(5)	Work tools	○	○	○
(6)	Measuring tools/digital measuring devices	○	○	○
(7)	Small, mobile workshops	○	○	○
(8)	Transport/vehicles for onsite emergency overhauls	○	○	○
(9)	Training devices, all types; OJT devices	○	○	○
(10)	Painting/washing equipment			○

Note: The exclamation points (○) indicate essential equipment.

2) Equipment Requested by Sindh Province

The equipment requested by Sindh Province is listed in the table below.

Table 3-30: Equipment Requested by Tandojam in Sindh Province (from oral surveys)

No.	Machinery/Equipment	Specific Devices
(1)	Engine performance testing equipment	Engine testing dynamometer, pressure washer, hydraulics & transmission tester
(2)	Vehicles for specialized work	Crane, forklift, utility cart
(3)	Equipment for diagnosing malfunctions & measurement equipment for bulldozers	Oil analysis system, ultrasound diagnostic equipment
(4)	Specialized welding devices	MIG welding machine, gas welding machine, submerged welding machine, semi-automatic welding machine
(5)	Tools for specialized work	Tools for link analysis and assembly work, depth gauge
(6)	Transport equipment	Lift fork, battery operated cart
(7)	Educational training, instruction, & facilities	OJT equipment, bulldozer measuring equipment, water purification equipment

3) Equipment Requested by Balochistan Province

The equipment requested by Balochistan Province is listed in the table below.

Table 3-31: Equipment Requested by Balochistan Province (Quetta, Khuzdar, and Turbat)

No.	Equipment	Quetta	Khuzdar	Turbat
(1)	Frame repair equipment	○		
(2)	Engine repair equipment	○	○	○
(3)	Diesel engine servicing/dynamometer	○	○	○
(4)	Fuel pump	○	○	○
(5)	Electrical system repair equipment	○	○	○
(6)	Battery servicing & repair equipment	○	○	○
(7)	Hydraulic system repair equipment	○	○	
(8)	Tire repair equipment	○		
(9)	Machine shop equipment	○	○	○
(10)	Welding, assembly equipment	○		
(11)	Assembly equipment for overhauling suspensions A. Roller, idler B. Track link	○	○	○
(12)	Parts warehouse	○	○	○
(13)	Room in which to store tools A. Measuring tools B. General tools C. Specialty tools	○	○	○
	Total Amount:	Rs 69.416 million ¥138.8 million	Rs 50.502 million ¥101.0 million	Rs 47.155 million ¥94.3 million

Note: The circles (○) indicate essential equipment. Exchange rate as of June 2004: Rs 1.00 = ¥2

Subsection 3.6.3: Examining the Appropriateness of the Detailed Requests

We have the feeling that they first noticed the lack of various types of equipment when they looked at the list of questions from Japan and then quickly put together a list of requests. Consequently, the nature of the requests was similar from facility to facility.

We will determine the appropriateness of equipment requests according to the following factors: the future volume of work (the number of bulldozers targeted for repair), the status of management for existing machines, plant management skills, the mechanics' technical skills, and whether or not they presently have the equipment.

From our field surveys, we determined that all repair facilities lack the funds and equipment to repair bulldozers. However, it would be unreasonable to provide the same assistance and full equipment to all repair facilities requesting this, in light of the volume of sustainable work for the repair facilities (such as the number of overhauls) and the current status of plant management capabilities. We believe it appropriate to provide the requested equipment to about four repair facilities.

Chart 3-32: Determining the Appropriateness of the Equipment Requested

Province	Repair Facility	# of Districts in Jurisdiction	Future Work Volume		Status of Management for Existing Machinery	Technical Capabilities of Repair Facilities			Need for Further Equipment	Space for Equipment	Total Findings)
			# of Bulldozers Targeted for Repairs	Finding		Plant Management	Technical Skills of Mechanics				
							Machining	Welding			
1. Punjab Province											
(1)	Mulran	10*	68	1	4	4	4	4	4	4	25
(2)	Faisalabad	7	52	1	3	2	2	4	4	4	20
(3)	Talagang	3	40	1	1	1	2	2	4	4	15
(4)	Lahore	10	40	1	2	2	2	2	4	4	17
(5)	Bahawalpur	3	29	1	4	4	4	4	4	4	25
2. Sindh Province											
(1)	Hyderabad	3	35	1	2	1	1	2	4	4	15
(2)	Kairpur	3	15	1	1	N.A.	N.A.	N.A.	4	4	10
(3)	Sukkur	4	4	1	1	1	1	1	4	4	13
3. Balochistan Province											
(1)	Quetta	17	113	1	3	4	4	1	4	4	21
(2)	Khuzdar	6	75	1	N.A.	N.A.	N.A.	N.A.	4	4	9
(3)	Turbat	3	32	1	1		1	1	4	4	12
4. NWFP											
(1)	D.I.Khan	6	0	1	N.A.	1	1	1	4	4	12
(2)	Peshawal	8	0	1	N.A.	1	1	1	4	4	12

Note: Determining criteria: 4, High; 3, Somewhat high; 2, Somewhat low; 1, Low.

The amount of work was determined by the number of bulldozers for which a single repair facility is responsible. (In Japan there are about 50,000 bulldozers in operation and 100 repair shops; 1 repair shop handles approximately 500 bulldozers.) Our findings were based on our field surveys and made on a qualitative basis. From the viewpoint of developable land, all repair facilities are important.

1) Determining the Appropriateness According to Workload
(Number of Bulldozers Targeted for Repairs)

We have received many requests for repair equipment from each of the repair facilities. However, it would be difficult for each repair facility to secure a sustainable workload even if the same equipment were supplied to all of them, in view of the number of bulldozers targeted for repair and the remaining useful economic life of those bulldozers. A certain level of workload is necessary in order to support the operating capacity of machines in a repair facility. For this reason, it will be necessary to reduce the number of facilities to be outfitted in order to ensure as large a workload as possible for these facilities.

For example, performing an overhaul five times per month is an appropriate workload for a repair facility. In order to achieve this, we should restrict our focus to about four main repair facilities. Anything greater than this would make sustainable management of the workshops difficult due to lack of workload.

The basis for our estimation of the number of main repair facilities is explained below:

(1) Engine Repair

Note: "OH" means "overhaul"; "WS" means "workshop"

- Workload: Overhaul of 5 units/month
  4,470,000 (total remaining operating time) ÷ (4,100 hrs (operating time until overhaul) × 4.7 years (avg. useful life))
  = 224 times/year (total number of overhauls/year)
  → 19 times/month

  19 times/month ÷ 4 WS = 4.75 → 1 WS performs OH 5 times/month

- # of Personnel Needed: <u>4 people</u>
  (Hours of work for 1 OH: 2 people × 2 weeks)

(2) Suspension Repair

- Workload: 10 sets (Repair the suspensions for 5 bulldozers. There is one set for each side of a bulldozer suspension; there are complete set suspensions.)

- # of Personnel Needed: 10 people

Consequently, if a repair facility performs five overhauls per month, they will need a total of 18 people: 14 for labor; one factory manager; one chief engineer; one QC manager; one general manager.

2) Determining the Appropriateness of the Repair Facility Management's Skills

As noted in Chapter 3, Section 3.3, Tables 3-13, 3-14, and 3-15, only three of the repair facilities have solid plant management capabilities: those in Bahawalpur, Multan, and Quetta. Management capabilities cannot be deemed sufficient at the other repair facilities.

However, it is necessary to work on improving plant operation and management at all facilities, including those listed above, once the nature of the duties has been determined. To be specific, plant management should standardize all duties; namely, 1) production planning; 2) quality control; 3) monitoring of work flow; 4) preventative maintenance; 5) reporting; 6) measures to prevent re-occurrence; 7) technical training; 8) plant income and expenditure reports. These should be managed by computer; they are an effective means of quality control on an ongoing basis.

3) Appropriateness of the Things Requested

Given the number of bulldozers, we have determined that it is not appropriate to focus on all repair facilities. We have designated four repair facilities with plant management capabilities, including the technical capabilities for relatively high-grade repairs using existing equipment and facilities. We have determined that aid for an engine overhaul workshop and a re-welding workshop (suspensions) is appropriate, as we stated in Subsection 3.6.1.

Below, we show what equipment should be provided to which repair facilities.

(1) Provide equipment to three repair facilities for specialized engine overhauls

Repair Facility	Province	Equipment to be Provided
Bahawalpur and Multan	Punjab	Machinery, tools, specialized measuring equipment for bulldozers, transport equipment: (1) Pressure washer (2) Dynamometer test stand (3) Specialized measuring equipment for bulldozers (4) Ceiling crane
Faisalabad	Punjab	
Quetta	Balochistan	

The equipment noted above was chosen for engine overhauls. The important steps of the overhaul process are as follows:

Step 1: Engine analysis. Gauge wear and points of breakdown, and determine which parts to remanufacture and which to exchange. These are done manually. (Specialized tools for analysis are necessary.)

Step 2: Wash parts. Use a semi-automatic pressure washer to control the force of the wash.

Step 3: Exchange wearable parts for new ones and assemble the engine. After assembling it, gauge it. This is done manually.

Step 4: Conduct a performance test after assembling the engine. An automatic dynamometer stand is used for this.

Step 5: Install the engine in the machine (bulldozer). A crane is used for this. Gauge the alignment after installation. The gauging is done manually.

(2) Provide equipment to four repair facilities for specialized welding refurbishment

The refurbishment and repair of welded parts (suspension) revolves mainly around welding and the handling of heavy objects. This requires equipment necessary for welding in bulldozers and cranes that can handle heavy objects.

Repair Facility	Province	Equipment Provided
Multan	Punjab	Welding machinery, tools, general purpose measuring equipment, transport equipment (1) MIG welding machine (2) Specialized submerged welding machine (3) Roller welder (4) Track press (5) Overhead crane (6) Jib crane (7) General purpose measuring equipment (caliper, micrometer, cylinder gauge, durometer, wear measurement gauge)
Faisalabad	Punjab	
Hyderabad	Sindh	
Quetta	Balochistan	

Subsection 3.6.4: Requisite Level of Technical Skills to Operate, Maintain, and Manage Repair Facilities

The equipment at repair facilities is closely related to the useful life of bulldozers and maintenance of bulldozer performance. Machinery, equipment, and parts (wearable parts) must be provided in order to equip a repair facility. In addition to fully equipping a facility with hardware such as a complete array of measuring devices, it is essential to make thorough improvements in "soft" factors such as testing facilities, recording, gauging (products), performance testing, quality control, and prevention and maintenance. Improvements made only on the "hard" side give rise to the concern that the equipment will revert to idle status in a few years' time.

Implementation of technical training, training in quality control, testing facilities, and performance testing conducted several times a year will prove instrumental in improving the "soft" aspects. An instructional manual for these aspects written in the local language is urgently needed. The table below details the problems common to all facilities, along with measures to resolve them and their levels of urgency.

Table 3-33: Chart Comparing Technical Level with Measures for Resolving Problems

	Item	Current Status	Cause	Measuring for Resolution	Ranking in Terms of Urgency
1. Servicing of Bulldozers					
(1)	Bulldozer servicing manual	None. Available for some equipment, but written in English; personnel are unable to read these.	Managers were unaware that these existed.	Education. Procure the English manuals from manufacturers & have them translated into the local language ASAP.	1
(2)	Specialized measuring equipment & tools	None. Substituting general-purpose measuring equipment.	Managers were unaware that these existed..	Re-education on the relationship between precision and product life.	2
(3)	Various servicing capabilities	Quite good.	Workers have a serious desire to work hard and learn.	Initiate local seminars on mechanics and technology.	3
(3)	Bulldozer performance checks	No measuring equipment.	Because this doesn't tie directly to profitability.	Install performance testing equipment and improve the quality of service.	1
(4)	Spot checks of finished products	None.	Quality control non-existent.	Conduct training on product quality.	2
(5)	Technical record and data maintenance	Insufficient.	No directives from management.	Create schedules and perform periodic checks.	3
2. Repair Facility Equipment					
(1)	General-purpose measuring equipment & tools	Almost none.	Had been lost.	Establish a tools room and maintain equipment.	2
(2)	Machining technology	Extremely random.	No technology advisor.	Institute a training system for mechanics.	3
(3)	Welding technology (particularly MIG welding)	Low across the board.	No welding technology advisor.	Conduct training in welding technology.	1

Note: Urgency ranking is from high to low, 1 being the highest and 3 being the lowest.

Section 3.7: Aid Necessary for Equipment Procurement

Subsection 3.7.1: Improving Maintenance Conditions

In order to operate repair facilities efficiently, we must ensure that the "soft" aspects of production are firmly in place (management capabilities and quality control[9]).

It is essential to provide educational materials by sourcing them from the producers of educational materials listed below, and to translate these into the local language:

(1) Bulldozer servicing manual
(2) Manual of maintenance standards
(3) CTS (Custom Track Service) checklist
(4) Educational materials for mechanics
(5) Comprehensive inspection manual
(6) Seminars and materials on technical skills

Additionally, equipment maintenance records should be kept; these should be used to clearly determine the cause for malfunctions and to prevent their re-occurrence.

Subsection 3.7.2: Technical Cooperation

As noted before, our current plans are to designate specific repair facilities, increase the specialized functions they offer, and provide technical assistance along with the equipment and tools needed for overhauling bulldozers. We also believe that it would be highly effective to accept research fellows and retrain them in Japan. The appropriate instructors for these seminars in Japan would be the ones on the front lines; namely, master mechanics and chief engineers.

Technical cooperation is required in the following areas:

(1) Seminars on basic knowledge pertaining to metalworking
(2) Technical training on quality control for bulldozers
(3) Technical training on welding technology

However, in order to provide such technical training, it is first necessary for engineering experts to conduct a detailed field survey, then create a training plan.

In addition to this, we see two options for conducting seminars. They are as follows:

[9]Management capabilities: Here, this means budget management, personnel allocation, preservation and maintenance management, inventory management, planning of work flow, work processes, etc. Quality control refers to have the technical skills to perform repairs with the proper repair technology.

(1) Send Pakistani technical personnel (managers, instructors and laborers) to Japan or to a local training institute.
(2) Conduct onsite training by sending several Japanese engineers to Pakistan for about one year, along with the equipment supplies.

In particular, option one would enable Pakistani personnel to understand the conditions at Japanese repair shops. We think this would be particularly effective for management seminars.

Master mechanic class personnel would be sent to six-week seminars. We feel that a total of eight people would be appropriate: four for machinery and four for welding.