6 IRRI Genebank

BONWOO KOO, PHILIP G. PARDEY AND MICHAEL T. JACKSON

History of the International Rice Genebank at IRRI

The rice genetic resources stored in the International Rice Genebank (IRG) at the International Rice Research Institute (IRRI) at Los Baños, the Philippines, represents the largest and most diverse *ex situ* collection of rice in the world (Jackson, 1997). The collection, estimated at more than 100,000 samples in 1999, is made up of landraces nurtured by farmers for generations, modern and obsolete varieties, some breeding lines and special genetic stocks, the 22 wild species in the genus *Oryza* and related genera in the tribe *Oryzeae*.

National and regional attempts were made during the 1950s to conserve rice genetic resources, including attempts to set up regional collections at three locations in Asia by FAO's International Rice Commission. After the establishment of a rice genebank within IRRI in the early 1960s, many countries donated duplicate samples for long-term storage there. Some of these efforts led to the collection of important genetic materials, such as the Assam Rice Collection, with more than 6600 samples assembled from north-east India in the late 1960s. Another set of germplasm was the deep-water varieties collected in Cambodia before the Khmer Rouge banned their cultivation. From the 1970s, the IRRI genebank began coordinating the collection of rice germplasm worldwide and the size of the collection has increased significantly since then. Between 1961 and 1974, the collection accumulated 28,000 accessions; by 1980 the collection had doubled, and then it almost doubled again in the next 20 years.

Between 1995 and 2000, with support from the Swiss Agency for Development and Cooperation (SDC), IRRI coordinated a major collection programme in 23 countries in South and South-east Asia, sub-Saharan Africa and Costa Rica. The aim of these joint collection activities was to complete, as far as possible, the field collection of cultivated rice germplasm by 2000, to explore areas that had previously been inaccessible (primarily

 Saving Seeds (B. Koo, P.G. Pardey and B.D. Wright *et al.*)

for reasons of civil unrest, which made collecting unsafe) and to enlarge the pool of wild germplasm in *ex situ* conservation. A particular effort was made to collect germplasm in the Lao People's Democratic Republic, a country where much of the existing rice cultivation (often of glutinous varieties) is based on indigenous rice, with thousands of different varieties (Appa Rao *et al.*, 1997). The Lao germplasm is now the second-largest component of the IRRI genebank collection.

The present genebank facilities were constructed in 1977 to establish the International Rice Germplasm Center (renamed as the International Rice Genebank in 1995) and became part of the Genetic Resources Center in 1990. Following extensive renovation and expansion in the early 1990s, significant improvements were made to ensure the long-term security of the germplasm collections. Today, IRG has two storage rooms (long- and medium-term), with a combined capacity for about 120,000 accessions (Table 6.1).

Costing the IRRI Genebank

Capital input costs

A breakdown of the capital costs related to the genebank facility and the costs of the operating equipment used by the IRRI genebank is provided in Table 6.2. The long-term (57-m^2) storage room is located in the middle of the medium-term storage room (whose net size is 182 m^2). Seeds for long-term

Table 6.1. IRRI genebank holdings, 1973–2001.

Year	Total number of accessions	Year	Total number of accessions
1973	24,162	1988	76,297
1974	26,818	1989	77,061
1975	30,332	1990	77,075
1976	34,229	1991	78,381
1977	36,956	1992	n/a
1978	40,768	1993	n/a
1979	47,743	1994	n/a
1980	53,431	1996	n/a
1981	57,027	1995	80,797
1982	60,181	1997	81,585
1983	63,490	1998	84,247
1984	64,744	1999	86,805
1985	66,836	2000	n/a
1986	71,878	2001[a]	91,025
1987	74,498		

[a]Includes only registered accessions as of August 2001.
n/a, not available.

Table 6.2. Capital input costs (US$, 1999 prices) at the IRRI genebank.

Cost category	Service life (years)	Replacement cost	Annualized cost[a]
Medium-term storage		**345,232**	**28,965**
Storage facility	40	150,440	7,308
Storage equipment	10	167,180	19,819
Heat-sealing device	10	2,440	289
Seed container	25	25,172	1,549
Long-term storage		**195,300**	**16,728**
Storage facility	40	56,418	2,741
Storage equipment	10	90,960	10,783
Vacuum-canning device	10	14,350	1,701
Seed container	50	33,572	1,503
Viability testing		**147,510**	**15,774**
Viability-testing facility	40	24,480	1,189
Germination chamber	10	106,000	12,566
Other equipment	10	17,030	2,019
Regeneration		**616,088**	**62,236**
Farming facility	40	76,500	3,716
Farming equipment	10	44,721	5,302
Screenhouse	10	222,042	26,323
Embryo-rescue facility	40	6,120	297
Embryo-rescue equipment	10	14,799	1,754
Seed-processing facility	40	65,280	3,171
Seed-cleaning equipment	10	16,350	1,938
Seed-drying facility	40	20,740	1,008
Seed-drying equipment	10	125,536	14,882
Vehicles	7	24,000	3,845
Seed-health testing		**37,601**	**3,422**
Seed-health testing facility	40	17,326	842
Lab/office equipment	10	17,503	2,075
Computer	5	1,092	236
Vehicle	7	1,680	269
General capital		**224,960**	**27,692**
General facility	40	103,360	5,021
Office equipment	10	30,000	3,556
Computer	5	79,600	17,193
Vehicle	7	12,000	1,922
Total capital cost		**1,566,691**	**154,817**

Note: See Appendix B for details.
[a]Calculated at a 4% interest rate using equation (3) in Appendix A.

storage are kept in vacuum-sealed aluminium cans, and seeds for medium-term storage are stored in heat-sealed aluminium-foil packets. Viability testing is performed year-round with a total of five germination chambers. A screenhouse of 4000 m^2 is used to cultivate wild varieties or those of low viability or in low stock. In addition, some dormant seeds and samples with particularly small quantities of seed are first seeded in an embryo-rescue room before being planted outside. All incoming and outgoing accessions

are tested for seed health by the Seed Health Unit (SHU), which occupies an area of 364 m^2, including reception, incubation and inspection areas. Annualized capital costs are shown in the right-hand column of Table 6.2, calculated using a 4% baseline interest rate.

Annual operating costs[1]

Seed storage

As of 1999, the total number of registered accessions of rice in the collection was 86,805, with a further 20,000 samples being multiplied prior to incorporating into the collection. About 94% of this collection consists of *Oryza sativa*, the rest are *Oryza glaberrima* (1.5%) and wild species (4.5%). Most accessions of seeds are stored both medium term as the active collection and long term as the base collection. For medium-term storage, materials are packed in aluminium-foil bags and stored at 2°C with a relative humidity of 30–35%. Materials for temporary storage (for example, planting or freshly harvested materials) are also stored in the medium-term storage room, in paper bags. The base collection is stored in vacuum-sealed cans maintained at about −18 to −20°C.

As for the other genebank operations at other centres described in earlier chapters, the variable cost of operating the storage facilities consists primarily of labour and electricity. Under the supervision of the genebank manager, the storage area's environment is monitored daily by a genebank technician. With an automatic power-supply system, the average time of running the storage equipment is 8 h/day, and the annual cost of electricity for storage amounts to $15,668 (Table 6.3).[2]

Viability testing

Existing stored seed, freshly regenerated seed and newly acquired seed are all tested for viability. Newly regenerated samples must retain a 90% or higher viability rate to be placed into long-term storage; if the germination of existing accessions falls below 85% of the initial rate, the accession is regenerated in the next growing season. A regular seed-testing schedule was established for all the species in IRRI's genebank based on the existing data set (Naredo *et al.*, 1998).

To test each accession, two 100-seed samples are placed in an oven at 50°C to break dormancy and then put on moist paper towels in a germination chamber with temperatures alternating between 30°C and 20°C under 99% relative humidity for a week before observation.[3] In a typical year, about 15,000 accessions from the storage rooms are tested, and an additional 7000–8000 freshly multiplied accessions are also tested before storage.[4] The amount of incoming material varies by year, but in the sample year of 1999 a total of 4950 accessions were newly introduced to IRG. The total number of genebank accessions tested for viability in 1999 was estimated to be 29,250. The viability testing is conducted by one technician with two contracted workers engaged year-round.

Table 6.3. Annual operating costs (US$, 1999 prices) of conservation and distribution at the IRRI genebank.

Cost category	Labour	Non-labour	Subtotal	Capital
Acquisition	**11,719**	**894**	**12,613**	**1,198**
Seed-health testing	4,435	588	5,023	
Seed handling	5,226	149	5,375	
Overheads	2,058	157	2,215	
(Number of accessions)			*(4,950)*	
Medium-term storage	**6,442**	**10,860**	**17,302**	**28,966**
Storage management	2,311	–	2,311	–
Climate control	3,000	8,953	11,953	
Overheads	1,131	1,907	3,038	
(Number of accessions)			*(86,080)*	
Long-term storage	**4,295**	**8,145**	**12,440**	**16,728**
Storage management	1,541	–	1,541	–
Climate control	2,000	6,715	8,715	–
Overheads	754	1,430	2,184	–
(Number of accessions)			*(83,930)*	
Viability testing	**10,142**	**437**	**10,579**	**15,774**
Viability testing	8,361	360	8,721	–
Overheads	1,781	77	1,858	–
(Number of accessions)			*(29,250)*	
Dissemination	**16,135**	**5,422**	**21,557**	**2,224**
Dissemination management	2,696	–	2,696	–
Seed-health testing	8,236	1,092	9,328	
Packing/shipping	2,370	3,378	5,748	
Overheads	2,833	952	3,785	
(Number of accessions)			*(6,200)*	
Duplication	**4,665**	**2,552**	**7,217**	
Packing/shipping	3,846	2,104	5,950	
Overheads	819	448	1,267	
(Number of accessions)			*(9,450)*	
Information management	**26,589**	**5,053**	**31,642**	
Database management	21,920	1,766	23,686	
Other expenses	–	2,400	2,400	
Overheads	4,669	887	5,556	
General management	**91,691**	**23,180**	**114,871**	**27,693**
Managerial staff	75,590	–	75,590	
Electricity	–	5,110	5,110	
Other expenses	–	14,000	14,000	–
Overheads	16,101	4,070	20,171	–
Total operating cost	**171,678**	**56,543**	**228,221**	**92,583**

Note: See Appendix B for further details.

Regeneration and characterization

To obtain high-quality seeds, regeneration is undertaken only in the dry season, between November and May, when conditions are most conducive for producing high-quality seeds with high viability. This season

offers high solar radiation, lower night temperatures and lower pest and disease pressure, as well as short days, which promote flowering in photoperiod-sensitive varieties (Ellis and Jackson, 1995; Kameswara Rao and Jackson, 1996).

Cultivated rice is regenerated in a 10-ha field in the IRRI experiment station. In 1999, a total of 7300 accessions were planted for regeneration, of which 4600 were for the multiplication of incoming materials and 2700 for multiplication or regeneration of existing materials. Most accessions of wild rice require different management practices for seed regeneration. Like other wild species, wild rice requires extra care in its regeneration (such as quarantine). These species, and a few cultivated ones, are regenerated in a screenhouse under the management of a scientist. Each accession is planted in separate seed boxes or pots, and 'selfing' (panicle bagging, as described in Chapter 4) is necessary to minimize outcrossing. Particular care is needed while harvesting wild rice to prevent seed loss from shattering and seed mixture. All these processes require extra labour and materials, making the overall costs of regenerating an accession of wild rice significantly higher than the cost of regenerating cultivated rice (Table 6.4).

Characterizing cultivated rice species is done during the rainy season when full vegetative characteristics are observed. Most farmers grow rice during the rainy season when the characteristics of species are well revealed. In 1999, 2000 accessions were characterized on a 2-ha area. The procedure of planting for characterization is the same as that for regeneration, except that materials are not harvested and a substantial amount of labour is needed for recording the traits of each accession. Morphological and agronomic characteristics are scored in small field plots during the wet season using a standard descriptor list. Almost 90% of the whole collection has been scored for about 50 morphological and agronomic characters.

Seed processing

After seeds are regenerated in the field and shipped to the seed-processing room, each accession is verified as representing the composition of the original sample and containing sufficient material for storage. Accessions of insufficient size revert to medium-term storage until they can be regrown the following season. Seeds are next dried for about a month in the seed drying room, which has a 9000-kg capacity and is operated at 15°C and 15% relative humidity. Seeds equilibrate slowly to a moisture content of around 6–7% (Jackson, 1997).

Dried seeds are pre-cleaned with blowers and then manually cleaned with sieves in the seed-processing room (at 20°C and 40–50% relative humidity). Seed cleaning is one of the most labour-intensive activities in IRRI's genebank operation; it is estimated that one technician can clean about two to five accessions per day.[5] Cleaned seed samples are divided into prelabelled envelopes for viability testing, seed-health testing, duplicate storage and prepacking, as well as for the active and base collections. Since rice seeds take in moisture during the cleaning process, they go through a final drying for a week.

Table 6.4. Annual costs (US$, 1999 prices) of regeneration and characterization at the IRRI genebank.

	Cultivated rice				Wild rice			
	Labour	Non-labour			Labour	Non-labour	Subtotal	
Regeneration	**145,233**	**11,164**	**156,397**	**41,704**	**23,399**	**1,226**	**24,625**	**20,533**
Field operation	**42,260**	**10,722**	**52,982**	**22,050**	**16,063**	**1,196**	**17,259**	**19,187**
Field management	7,056	–	7,056	20,819	6,048	–	6,048	18,366
Seed preparation	400	73	473	–	820	5	825	–
Embryo rescue	1,536	957	2,493	1,231	1,024	638	1,662	821
Land preparation	4,198	1,322	5,520	–	600	–	600	–
Seeding	707	–	707	–	300	–	300	–
Transplanting	2,615	–	2,615	–	700	–	700	–
Pest control	5,511	3,327	8,838	–	450	59	509	–
Irrigation/fertilization	972	2,430	3,402	–	300	184	484	–
Purification	686	–	686	–	800	50	850	–
Harvesting	7,298	730	8,028	–	1,600	50	1,650	–
Threshing/cleaning	3,860	–	3,860	–	600	–	600	–
Overheads	7,421	1,883	9,304	–	2,821	210	3,031	–
Seed processing	**102,974**	**443**	**103,417**	**19,653**	**7,336**	**30**	**7,366**	**1,346**
Process management	7,242	–	7,242	2,968	462	–	462	203
Seed drying/cleaning	75,460	365	75,825	16,685	5,436	25	5,461	1,143
Medium-term packing	730	–	730	–	50	–	50	–
Long-term packing	1,460	–	1,460	–	100	–	100	–
Overheads	18,082	78	18,160	–	1,288	5	1,293	–
(Number of accessions)			*(7,300)*				*(500)*	
Characterization	**10,978**	**1,735**	**12,713**		**1,951**		**1,951**	
Field operation	5,034	1,430	6,464		–		–	
Recording traits	4,016	–	4,016		1,608		1,608	
Overheads	1,928	305	2,233		343		343	
(Number of accessions)			*(2,000)*				*(500)*	

Note: See Appendix B for further details.

For the base collection, seeds are then packed in two 60-g-capacity aluminium cans per accession; for the active collection, samples are stored in resealable laminated aluminium-foil bags (about 500 g); and, for safety duplication, 20-g seed samples are packed in small aluminium packets. Two to five 10-g packets are also prepared at this time ready for dissemination. The amount of stored seeds for wild species is much smaller than for cultivated species: about 50 seeds for the base collection and 10–20 seeds for dissemination.

Seed-health testing

All incoming and disseminated samples are examined by the Seed Health Unit (SHU) under the supervision of the Philippine Plant Quarantine Service, Bureau of Plant Industry. Formerly, seeds were tested for health just before dissemination; however, since the mid-1990s, newly regenerated samples are tested before storage, and if these samples are requested they are directly disseminated without extra testing.[6] The motivation for this change in protocol is to store only the highest-quality seeds, thereby saving on storage costs.

Under a part-time manager, four scientists and eight technicians verify the health of seed used by the genebank, the International Network for the Genetic Evaluation of Rice (INGER) activity and the breeding programme. In 1999, the SHU tested 12,195 incoming and 57,720 outgoing accessions, of which 3469 and 6200 accessions were destined for or came from the genebank, respectively. Thus, the genebank's share of the total number of accessions processed by the SHU was estimated at 14% – the amount allocated in our calculations.

Dissemination and safety duplication

Seeds that are disseminated from IRRI come either from the genebank, which distributes mostly landraces and raw materials, or through INGER, which sends élite germplasm to further national breeding objectives (Jackson *et al.*, 2000). Since 1973, more than 775,000 packets of seeds have been disseminated worldwide. Fewer than 17,000 of the accessions registered in the genebank have never been requested (Table 6.5).[7] In addition to a Philippine phytosanitary certificate, accessions disseminated internationally require an import permit from the requesting country. A local phytosanitary certificate is required for shipments within the Philippines.

Ninety-five per cent of IRRI genebank accessions are duplicated at the US National Seed Storage Laboratory in Fort Collins via the black-box method described in Chapter 3. Duplicate storage of African rice is shared between IRRI, the International Institute of Tropical Agriculture (IITA) in Nigeria and the Africa Rice Center (WARDA, formerly the West Africa Rice Development Association) in the Ivory Coast. The seeds destined for backup storage are packed at the same time as those kept in on-site storage and dissemination, and so the labour cost involved in duplicating and disseminating seed is similar.

Table 6.5. Dissemination of germplasm from the IRRI genebank, 1991–1999.

Number of samples	**31,539**	**16,229**	**25,289**	**25,802**	**15,630**	**10,958**	**5,633**	**6,670**	**6,194**
Oryza sativa									
Dissemination	**31,539**	**14,895**	**22,893**	**24,783**	**14,552**	**8,033**	**4,371**	**5,474**	**5,027**
GRC in IRRI	356	2,522	2,488	2,187	2,343	1,660	816	1,935	2,663
Elsewhere in IRRI	25,596	6,421	11,873	11,915	7,590	4,084	2,200	1,117	674
Outside IRRI	5,587	5,952	8,532	10,681	4,619	2,289	1,355	2,422	1,690
Safety duplication	**4,530**	–	**8,608**	–	**5,435**	–	–	**11,727**	**8,343**
Oryza glaberrima									
Dissemination	–	**31**	**247**	**38**	**220**	**275**	**216**	**216**	**35**
GRC in IRRI	–	1	2	–	200	197	172	191	1
Elsewhere in IRRI	–	3	14	23	3	–	–	–	–
Outside IRRI	–	27	231	15	17	78	44	25	34
Safety duplication	–	–	**88**	–	**24**	–	–	**136**	**262**
Wild rice									
Dissemination	–	**1,303**	**2,149**	**981**	**858**	**2,650**	**1,046**	**980**	**1,132**
GRC in IRRI	–	–	190	–	13	1,867	380	104	439
Elsewhere in IRRI	–	344	130	303	140	124	146	14	32
Outside IRRI	–	959	1,829	678	705	659	520	862	661
Safety duplication	–	–	–	–	**1,802**	–	–	**245**	**842**
Number of shipments	**270**	**292**	**288**	**265**	**232**	**215**	**144**	**176**	**186**
Oryza sativa									
Dissemination	**270**	**241**	**226**	**223**	**186**	**149**	**108**	**128**	**141**
GRC in IRRI	14	16	20	12	14	12	12	12	12
Elsewhere in IRRI	141	105	83	101	82	52	42	48	66
Outside IRRI	115	120	123	110	90	85	54	68	63
Oryza glaberrima									
Dissemination	–	**10**	**15**	**8**	**9**	**11**	**9**	**12**	**7**
GRC in IRRI	–	1	1	–	1	1	3	1	1
Elsewhere in IRRI	–	1	5	3	3	–	–	–	–
Outside IRRI	–	8	9	5	5	10	6	11	6
Wild rice									
Dissemination	–	**41**	**47**	**34**	**37**	**55**	**27**	**36**	**38**
GRC in IRRI	–	–	4	–	2	21	4	2	12
Elsewhere in IRRI	–	10	10	14	12	6	5	2	6
Outside IRRI	–	31	33	20	23	28	18	32	20

GRC, Genetic Resources Centre.

Data and information management
Documentation and data management were significantly enhanced during the 1990s through the development of the International Rice Genebank Collection Information System (IRGCIS), which operates on IRRI's local area network, using Oracle as the software platform. Its value has been further strengthened through integration with the CG's SINGER database. The recent launching of a Web-enabled version of the IRGCIS has expanded access to IRRI's germplasm data.

Economic Analysis

Representative annual costs of genebank operation

The total cost of operating the rice genebank at IRRI is estimated at $578,727 in 1999, including the operational costs related to conservation and distribution. Capital expenses constitute only a quarter of the annual operating costs, and labour accounts for more than 60%, including the costs of scientific and senior technical staff engaged in genebank operations, which we consider as quasi-fixed (labour) costs (Table 6.6 and Fig. 6.1).

Economic costs

Annual average costs
The average cost of holding over an accession of any crop for one more year, if initial regeneration is deemed unnecessary, is just 24 cents; if regeneration is required, the cost jumps to between $13.79 for cultivated rice and $34.09 for wild rice. Keeping a newly introduced accession in its first year costs between $21.70 and $42.00 per accession. Disseminating seed samples, if there is sufficient stock in the active collection, costs $8.66 per accession. If regeneration is needed to boost stocks, distribution costs per accession jump to $22.21 for cultivated rice and $42.51 for wild rice. The cost of disseminating newly acquired sample ranges from $31.50 to $49.34 per accession due to the costs involved in characterizing newly acquired material (Table 6.7).

Average costs in the long run
Table 6.8 provides present values for the costs of conserving and distributing an accession in perpetuity (once again, in constant, inflation-adjusted terms). In keeping with the procedures used for estimating costs at other CG centres, we used a 4% baseline interest rate and assumed that viability testing begins in the 10th year after acquisition, that retesting occurs every 5 years thereafter and – in the case of IRRI – that an accession is disseminated once every 10 years.

Under these assumptions, the average cost of conserving an existing accession (not needing regeneration) in perpetuity at IRRI is $10.58 for culti-

Table 6.6. Annual total (US$, 1999 prices) and average (US$ per accession, 1999 prices) costs of each operation at the IRRI genebank.

Cost category	Number of accessions	Total capital cost	Total quasi-fixed cost[a]	Total variable cost	Average capital cost	Average quasi-fixed cost	Average variable cost
Medium-term storage	86,080	33,120	18,509	20,770	0.38	0.22	0.24
Long-term storage	83,930	18,113	7,104	12,661	0.22	0.08	0.15
Acquisition	4,950	3,967	15,808	11,455	0.80	3.19	2.31
Viability testing	29,250	18,544	12,807	12,423	0.63	0.44	0.42
Dissemination	6,200	7,763	29,786	21,074	1.25	4.80	3.40
Safety duplication	9,450	1,385	6,637	7,906	0.15	0.70	0.84
Regeneration							
Cultivated rice	7,300	48,350	42,880	148,680	6.62	5.87	20.37
Wild rice	500	22,195	16,896	16,520	44.39	33.79	33.04
Characterization							
Cultivated rice	2,000	1,108	9,079	9,494	0.55	4.54	4.75
Wild rice	500	277	2,270	1,146	0.55	4.54	2.29
Total cost		**154,822**	**161,776**	**262,129**			

Note: Information and general management costs are allocated according to the following percentages for the IRRI genebank: medium-term storage (15%), long-term storage (5%), acquisition (10%), viability testing (10%), regeneration (30%), characterization (5%), duplication (5%) and dissemination (20%).
[a]Total quasi-fixed cost includes the cost of senior scientific and technical staff.

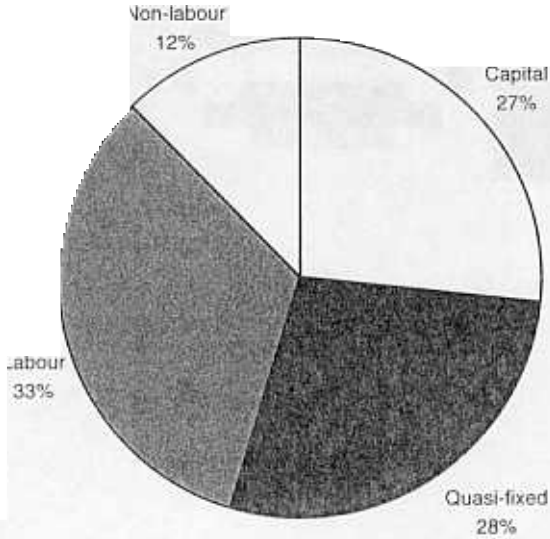

Fig. 6.1. Representative annual costs of maintaining the IRRI genebank holdings. Share of conservation and distribution costs by cost category (US$578,727, 1999 prices).

vated rice and $13.90 for wild rice. For a newly acquired accession or one needing initial regeneration, the conservation costs range from $32.04 to $55.66 per accession. The present value to distribute an accession ranges from $51.19 to $72.23 if an initial regeneration is not required, while distributing a newly acquired accession of rice costs between $74.03 and $112.91.

Total costs in the long run

The present-value equivalent of $1,285,255 and $1,959,936 are needed to underwrite the capital costs of conserving and distributing IRRI's current collection in perpetuity, respectively. Labour and operating costs to conserve and distribute the entire holdings in perpetuity would require a total of $2,857,157 and $6,550,944, respectively, in present values (Table 6.9). We estimate that overall it costs $4,142,412 to conserve and $8,510,880 to distribute the current level of holdings in the IRRI genebank in perpetuity, representing a total of $12,653,292.

Notes

[1]Jackson (2000) discusses the details of the IRRI genebank operations.

[2]This is denoted as 'climate control' costs in Table 6.3. In addition to the use of electricity for storage purposes, the cost of electricity used for general purposes is included as part of the general management category.

Table 6.7. Average costs (US$ per accession, 1999 prices) of conserving and distributing an accession for 1 year at the IRRI genebank.

Cost category	Existing accession		New accession[a] (with regeneration)
	Without regeneration	With regeneration	
Conservation			
Long-term storage	0.24	0.24	0.24
New introduction			
Acquisition			5.51
Initial viability testing			0.86
Initial duplication			1.54
Viability testing		0.43	0.43
Regeneration[b]			
Cultivated rice		13.12	13.12
Wild rice		33.42	33.42
Conservation cost			
Cultivated rice	**0.24**	**13.79**	**21.70**
Wild rice	**0.24**	**34.09**	**42.00**
Distribution			
Medium-term storage	0.46	0.46	0.46
Dissemination	8.20	8.20	8.20
Viability testing		0.43	0.43
Regeneration			
Cultivated rice		13.12	13.12
Wild rice		33.42	33.42
Characterization			
Cultivated rice			9.29
Wild rice			6.83
Distribution cost			
Cultivated rice	**8.66**	**22.21**	**31.50**
Wild rice	**8.66**	**42.51**	**49.34**

[a]Newly introduced accessions require initial regeneration and viability testing.
[b]Regeneration costs are equally allocated between conservation and distribution.

[3]For wild rice, only 20 seeds are tested after breaking dormancy.
[4]The entire collection was tested for viability over several years from the mid-1990s, and more than 600,000 germination tests were made over that time.
[5]The target seed quantity after drying is about 1 kg per accession; assuming 40 seeds weigh 1 g, each accession of cultivated rice consists of 40,000 seeds.
[6]Accessions placed in medium-term storage prior to mid-1990 were not necessarily subject to health testing and thus are tested prior to dissemination.
[7]Some are requested repeatedly, such as IRGC328 (a variety named Azucena), reflecting their common and widespread use in molecular mapping and genomics.

Table 6.8. Present values (US$ per accession, 1999 prices) of conserving and distributing an accession in perpetuity at the IRRI genebank.

	Existing accession[a]			New accession		
Cost category	2%	4%	6%	2%	4%	6%
Conservation						
Long-term storage	12.01	6.12	4.16	12.01	6.12	4.16
New introduction						
Acquisition				5.51	5.51	5.51
Initial viability testing				0.86	0.86	0.86
Initial duplication				1.54	1.54	1.54
Viability testing[b]	4.14	1.99	1.28	4.14	1.99	1.28
Safety duplication[c]	0.91	0.25	0.09	0.91	0.25	0.09
Regeneration (50 years)						
Cultivated rice	8.01	2.22	0.78	21.56	15.77	14.33
Wild rice	20.01	5.54	1.94	53.86	39.39	35.79
Conservation cost						
Cultivated rice	**25.07**	**10.58**	**6.31**	**46.53**	**32.04**	**27.77**
Wild rice	**37.07**	**13.90**	**7.47**	**78.83**	**55.66**	**49.22**
Distribution						
Medium-term storage	23.27	11.86	8.06	23.27	11.86	8.06
Dissemination[d]	45.66	25.28	18.58	45.66	25.28	18.58
Regeneration (25 years)						
Cultivated rice	34.30	14.05	7.46	47.85	27.60	21.01
Wild rice	85.66	35.09	18.62	119.51	68.94	52.47
Characterization						
Cultivated rice				9.29	9.29	9.29
Wild rice				6.83	6.83	6.83
Distribution cost						
Cultivated rice	**103.23**	**51.19**	**34.10**	**126.07**	**74.03**	**56.94**
Wild rice	**154.59**	**72.23**	**45.26**	**195.27**	**112.91**	**85.94**

Note: The data in this table were calculated using equations (1) and (2) in Appendix A.

[a]Existing accessions are assumed to have been freshly regenerated. New accessions require initial regeneration.

[b]Viability testing commences in the 10th year after acquisition, and then every 5 years thereafter.

[c]Safety duplication is made concurrently with each round of regeneration.

[d]Dissemination occurs every 5 years.

Table 6.9. Total costs of conservation and distribution in perpetuity at the IRRI genebank.

Crop/cost category	Number of accessions	Per-accession cost (US$ per accession, 1999 prices)			Total cost (US$, 1999 prices)		
		Conservation	Distribution	Total	Conservation	Distribution	Total
Cultivated rice	83,600	**46.05**	**95.20**	**141.25**	**3,849,174**		**11,807,908**
Non-capital		32.05	74.04	106.09	2,679,030		8,868,624
Capital		14.00	21.16	35.16	1,170,144		2,939,284
Wild rice	3,200	**91.63**	**172.54**	**264.17**	**293,238**		**845,384**
Non-capital		55.66	112.92	168.58	178,127		539,477
Capital		35.97	59.62	95.59	115,111		305,907
All crops	**86,800**	**137.68**	**267.74**	**405.42**	**4,142,412**		**12,653,292**