ECONOMIC AND FINANCIAL ANALYSIS

A. Approach and Methodology

1. The output of the project, mainly reflected in the analysis is project output 1, which is to build Khamza new pump station, and modernize and rehabilitate the following existing four pump stations: Khamza 2, Kuyu Mazar, Kizil Tepa, and Kizil Tepa Auxiliary. The analysis also reflects the maintenance cost of repairing the discharge pipes of these existing four pump stations to be modernized and rehabilitated under the project. This maintenance cost is to be borne by the Government of Uzbekistan. Other project outputs included in the analysis are output 2 (i.e. conveyance efficiency in the Amu Bukhara Irrigation System (ABIS) main canal increased), output 3 (i.e. the capacity of basin irrigation system administration, irrigation system administrations, water consumers' associations, and farmers to adapt to climate change increased), and output 4 (i.e. project and ABIS managed efficiently) including provisions of a decision support system (DSS) and supervisory control and data acquisition (SCADA), and management of and activities to support implementation. The main economic benefit of the project would be to maintain existing levels of agricultural production in most parts of the project area and to prevent the decline that would occur if the existing pumps were not replaced. More efficient pump equipment will also generate substantial energy savings. The project will focus on three irrigation schemes that cover about 250,000 hectares (ha) within the overall ABIS area of 315,000 ha.

B. Key Assumptions

2. All investments and benefits have been valued at late 2012 prices. Border parity prices based on World Bank price projections were prepared for traded commodities such as cotton, fertilizers, and wheat. All prices for non-traded commodities were based on current market prices. A shadow value of 0.8 was applied to normal agricultural wage rates, but not to the rate for cotton harvesting where it is becoming increasingly difficult to find sufficient labor. A markup of 20% was applied in the economic analysis to standard farm machinery rental charges, which are considered to be rather low and generally below the costs of replacement. A standard conversion factor of 0.8 was applied to the local currency portion of capital costs. The current price for power of SUM112.2 per kilowatt-hour was applied in the base case economic analysis.[1]

C. Project Benefits

3. This project focused on providing sustainable, reliable water supplies and is unlikely to make any significant contribution towards improved cropping productivity. Project benefits will be derived from (i) avoiding crop losses that would occur if the existing pump stations were not replaced, or modernized and rehabilitated; (ii) increasing water conveyance efficiencies by modernizing and rehabilitating the Amu Bukhara main canal structures and improving system management through the DSS and SCADA interventions; and (iii) reducing power consumption by providing more efficient pump equipment.

4. **Without project**. All the large pumps within the project pump stations are 38-48 years old. Assessment reports prepared by ADB's consultant generally indicate that all are in either worn or in critical condition. Despite the occasional pump and discharge pipe breakdown and periods when water flow from the Amu Darya River is insufficient, the land serviced by the ABIS

[1] The economic price of water is based on the electricity cost for pump operations.

continues to be irrigated. Nonetheless, the pumps continue to operate only with skilled, innovative maintenance. Two without-project scenarios were identified for the analysis to project the extent of potential future system decline. The base case scenario assumed that annual pumping hours will begin to slowly decline within a few years, depending on the current age of the individual pumps. The base case assumed that the operational hours of the pumps at the Khamza 1 and Kuyu Mazar pump stations, which were constructed in 1965, would start declining in year 4 from 2013. The declines for the increasingly heavily used Khamza 2 station pumps would begin in year 6 from 2013, and drops in output from the two less-worn Kizil Tepa station pumps would start in year 7 from 2013. Sensitivity analysis, based on delays of the decline onset period, was undertaken. The second, more pessimistic scenario assumed that the pumps within a given pump station would fail totally in year 1–4 from 2013. Differing breakdown dates were assigned according to a pump's age and use. The consequences of the reductions in pumping capacity under both scenarios were calculated in terms of areas irrigated, and schedules of declining net farm income were prepared up to year 25 from 2013.

5. **With project**. The with-project assessment assumed that present cropping and cropping intensities could be maintained at current levels for the main part of the project area after the replacement or rehabilitation of the pump stations under the project. Because some of the pumps at the two Kizil Tepa pump stations will not be replaced under the project, it was assumed that part of the area they now irrigate will eventually no longer be served.[2] Substantial energy cost savings were assumed once the new energy-efficient pumps begin operating. Maintenance costs were assumed to rise considerably because the new machinery to be provided under the project will be much more complex than current equipment and less tolerant of the less sophisticated maintenance practices now in use. Some savings in the amount of water used for irrigation were also assumed to result from improved pump reliability, improved main canal structures, and the provision of management facilities.

D. Financial Analysis

6. **Study area.** The total area served by the ABIS is about 315,000 ha. The project is likely to have a direct impact on about 225,000 ha within three irrigation schemes.[3] The schemes and areas covered by the project and studied are (i) Karaul Bazar—about 16,000 ha within the Bukhara Province; (ii) Kuyu Mazar—about 91,000 ha within the Bukhara Province; and (iii) Kizil Tepa—about 119,000 ha within the Bukhara and Navoi Provinces.

7. **Crops and cropping intensities**. State-controlled cotton and wheat represent about 39% and 26% of the total cropped land in the project area, respectively. About half of the wheat area is used after harvest to grow short-term secondary crops, and virtually all the non-wheat land that is not occupied by cotton or perennial crops is also used to grow crops of the farmers' choice. About 10% of the area irrigated by the ABIS is covered by perennial crops (grapes, mulberries, and other fruit). Overall cropping intensity is about 108%.

[2] As a result of unavailability of fully required financing for the modernization and rehabilitation of four existing pump stations, the two pump stations will be partly modernized and rehabilitated (i.e. 85% and 60% against total required cost for Kizil Tepa pump station and its auxiliary pump station, respectively).

[3] The command area of 250,000 ha will be benefitted by the construction of the new Khamza pump station and the modernization and rehabilitation of the Khamza 2 pump station, both of which will boost the supply of irrigation water to other project pump stations. However, 25,000 ha of the command area is excluded from the study area considering these are indirect benefitted area since pumps serving 25,000 ha at the Kizil Tepa and its auxiliary pump stations will not be modernized rehabilitated under the project.

8. Cropping patterns and intensities vary between the schemes within the ABIS. Based on a detailed breakdown of secondary crops and on the large area described as homestead land, vegetables occupy about 18% of the overall cropped area.[4] Fodder crops, alfalfa, and maize silage occupy another 16%.[5]

9. **Crop yields**. The yields of seed cotton (about 3.2 tons per ha) and of wheat (about 6.0 tons per ha) in the Bukhara Province are among the highest yielding in the country. This indicates that the natural soil fertility levels in this Province are better than the official classification might suggest. Yields for vegetables, fruit, and fodder appear to be similar to those achieved in other areas of the country.

10. **Salinity and waterlogging.** The analysis distinguished between study areas where no significant salinity, waterlogging, or water shortage constraints exist and those that have such problems. About 12% of the total area is now classified as having unsatisfactory cropping potential due to salinity, high groundwater, or water shortages. The government's Amelioration Fund[6] and the ongoing ADB-financed Land Improvement Project to reduce soil salinity are currently being implemented in the project area, and they should soon provide benefits whether the project goes ahead or does not.[7] No project-induced improvements in cropping productivity were considered in this analysis while this impact has been incorporated in the analysis under both the with- and the without-project scenarios in terms of a projected reduction in the percentage of cropped area that is affected by poor growing conditions to about 5% by 2015.

11. **Crop budgets.** Crop budgets in financial and economic terms were prepared for wheat, cotton, cucumbers, maize silage, and mature peaches. The latter three crops were selected as representatives of their crop category after calculating the returns for a range of the main crops within each crop category and weighting them according to cropped area. Table 1 summarizes the estimated financial returns per ha for normal and marginal lands.

Table 1: Financial Returns, 2012
(SUM'000 per hectare)

	Land Condition	
Crop	**Good**	**Marginal**
Cotton	448	205
Wheat	807	378
Vegetables	2,418	1,073
Fruit	2,283	1,010
Fodder	2,173	1,056

Source: Asian Development Bank estimates.

12. According to the crop budgets calculated by the consultant by incorporating details of inputs used and unit costs and values, cotton and wheat production are heavily mechanized, except for the cotton harvest, which is usually performed manually.[8] No costs for the irrigation water have been included because it is provided free of charge to the farmer by the

[4] Predominantly cabbage, carrots, cucumbers, melons, onions, potatoes, and tomatoes.
[5] Fodder crops comprise mainly short- and long-term pasture.
[6] In 2007, the government established the Amelioration Fund to improve drainage conditions and address waterlogging and soil salinity problems.
[7] ADB. 2007. *Report and Recommendation of the President to the Board of Directors on Proposed Loan to the Republic of Uzbekistan for Land Improvement Project.* Manila.
[8] ADB. 2011. *Technical Assistance to the Republic of Uzbekistan for Preparing the Amu Bukhara Irrigation System Rehabilitation Project (Consultant Final Report and Supplementary Report)*. Manila (TA 7917-UZB).

government. The economic costs of water were included elsewhere in the analysis. Land is allocated free of charge to farmers, who for the most part do not own it.

13. Financial returns of cotton and wheat are rather low, but the water and land are provided at no cost, mechanization facilities are provided at subsidized rates, and one-third of each holding can be used to grow crops of the farmer's choosing. Returns from the main crops of vegetables and fruit appear to be very attractive. While the analysis placed a financial value on fodder, in reality most of these crops are consumed by the farmers' own livestock. Large numbers of sheep, goats, and cattle are found in the project area.

14. The net economic returns per ha of cotton are considerably higher than the financial returns, reflecting the fact that the government purchases all the cotton at prices it determines. The differences between the financial and economic returns for wheat and the other crops are relatively small.[9]

15. **Farm size.** The study area is estimated to have 2,570 micro farms smaller than 50 ha; 1,100 small farms of 50 ha–100 ha; and up to 25 large farms larger than 100 ha. Average farm size is about 67 ha. For analysis purposes, it was assumed that the three typical farm sizes would be 50 ha, 100 ha, and 200 ha. The number of farms has declined dramatically in the Bukhara Province from more than 15,000 holdings in 2007 to fewer than 4,000 now.

16. **Without-project irrigation scenarios**. The 16,000 ha Karakul Bazar irrigation scheme gets first call on the water being pumped from the Khamza 1 and Khamza 2 pump stations. It is likely that, even without the project, many years would pass before supplies to most farms under this scheme would be reduced. The stage 2 pumps supplying this area are in good condition, and their replacement is not envisaged under the project. For individual farms within the Kuyu Mazar and Kizil Tepa irrigation schemes, the without-project impact would depend on how the declining water volume was allocated between the two schemes, the rate at which the stage 2 pumps deteriorated, and where the farms are. It is likely that farms located near the heads of the main canals feeding the irrigation areas, in Kizil Tepa, Vobkent, Gidjuvan, Kagan, and Bukhara districts, would be impacted least and those in the districts farthest from the main canals would be impacted most. Although it is envisaged that attempts would be made to spread the declining water flow among all farmers, a more realistic scenario is one in which the farms located farthest from the main canals would cease to function first. The problem would gradually spread upstream toward the main irrigation canal outlets as water supplies diminished. With so little rainfall, the opportunities for farmers to adjust their cropping patterns in the face of declining irrigation supplies are virtually nil. Applying these assumptions under the second of the two scenarios—total failure of the pump stations during year 1–4 from 2013—all cropping would cease by around year 11. Under the more conservative scenario of gradual decline, about 20% of the survey area would remain productive up to and beyond year 25 from 2013. For the farmers who would lose their water under either scenario, the without-project impact would be a total loss of agricultural production. The annual benefit they would gain if the project goes ahead would come not only from the value of the crops saved but also through the safeguarding of their investments, such as those made in perennial crop establishment, in land improvement, in farm-level irrigation, and in on-farm access infrastructure improvement.

17. **Returns per average farmed hectare.** The likely average return per ha for lands cropped in the three study area irrigation schemes is given in Table 2. It was assumed that by the time the project begins, about 95% of the irrigated area will be capable of producing good

[9] Half of the wheat crop is purchased by the government.

crops and around 5% of the area will be of marginal productivity. Although there are some differences in cropping patterns between irrigation schemes, the calculations indicate that average returns are very similar and average out at about SUM1,370,000 per ha ($500 per ha).

Table 2: Financial Returns on Irrigated Farms in Project Area
(SUM'000 per hectare)

Item	Cotton	Wheat	Vegetables	Fodder	Perennial	Total
Good Land						
Overall return/ha	448	807	2,418	2,173	2,283	
Kizil Tepa	157	206	429	330	220	1,341
Kuyu Mazar	172	176	401	353	242	1,344
Karaul Bazar	153	305	160	610	25	1,253
Average	163	201	399	359	215	1,336
Marginal Land						
Overall return/ha	205	378	1,073	1,056	1,010	
Kizil Tepa	4	5	10	8	5	32
Kuyu Mazar	4	4	9	9	6	32
Karaul Bazar	4	8	4	15	1	30
Average	4	5	9	9	5	32
All Land						
Kizil Tepa	161	211	439	338	225	1,373
Kuyu Mazar	177	180	410	362	248	1,376
Karakul Bazar	156	313	163	625	26	1,284
Average	**167**	**205**	**408**	**368**	**220**	**1,368**

ha = hectare.
Source: Asian Development Bank estimates.

18. **Net farm returns**. The analysis assumed the same cropping patterns for the three land holding sizes, and the net annual returns projected for the three farm sizes are presented in Table 3. The analysis assumed that all farms would produce these annual levels unless or until irrigation water was no longer available (under the without-project scenario), at which point all production would cease. Experiences on individual farms would naturally vary, depending on the rate in decline of water supply, but it was assumed that once the water supply started to decline, complete farm failure would quickly ensue.

Table 3: Average Financial Returns on Irrigated Farms in Project Area
(SUM'000 per farm)

	Farm size (ha)		
Study Area	**50**	**100**	**200**
Kizil Tepa	68,663	137,325	274,651
Kuyu Mazar	68,803	137,605	275,211
Karaul Bazar	64,194	128,388	
Average	68,403	136,805	274,893

ha = hectare.
Source: Asian Development Bank estimates.

19. The data presented in Tables 2 and 3 apply to both the with- and without-project scenarios as no changes in the current cropping patterns or productivity have been assumed in the with-project scenario. Farms will operate similarly until the water fails to reach the farm, at which point all production will cease.

20. **Labor use**. Despite heavy mechanization, production of the crops grown in the project area requires a substantial amount of manual labor. The weighted average use for the overall cropping pattern is about 55 workdays per ha per year, including 13 workdays for picking cotton. A daily wage of SUM12,000 was used for general labor costs and SUM15,000 (net of tax) for cotton picking. Thus average annual labor cost per cropped ha was around SUM700,000. In the without-project scenario, this would be the revenue lost to the local economy for every ha falling into disuse. On a weighted average basis, the daily cost of labor is about SUM12,700 per day.

21. **Overall financial impact.** Table 4 summarizes the anticipated overall financial impact the reduced cost option investment would have over a 25 year period, based on an assumed water supply decline scenario that pumps would fail gradually, rather than catastrophically. It indicates that over a 25 year period, the net financial farm income saved would be about $1.33 billion.

22. With regard to manual labor, the total value of wages saved as a consequence of project implementation would be about $679 million, or 112 million workdays.

Table 4: Total With-Project Saved Financial Farm Returns and Manual Wages, Reduced Cost Option

Item	Unit of Measurement	1	5	10	15	20	25	Total
Farm returns								**25 years**
Irrigated area WOP	ha'000	241	213	154	111	77	50	
Return/ha/yr	SUM million	1.37	1.37	1.37	1.37	1.37	1.37	
Total WOP return/yr	SUM billion	330	291	211	152	105	69	4,703
Irrigated area WP	ha'000	241	213	217	217	217	217	
Return/ha/yr	SUM million	1.37	1.37	1.37	1.37	1.37	1.37	
Total WP return/yr	SUM billion	330	291	296	296	296	296	7,492
Net WP saved income/yr	SUM billion	-	-	85	144	191	228	2,789
Net WP saved income/yr	$ million	-	-	41	69	91	109	1,331
Labor (manual)								
WOP labor use	workdays million	13	12	8	6	4	3	189
WOP labor wages	SUM/yr	13	13	13	13	13	13	13
Total WOP wages	SUM billion	168	149	108	78	54	35	2,401
WP labor use	workdays million	13	12	12	12	12	12	301
WP labor wages	SUM/yr	13	13	13	13	13	13	13
Total WP wages	SUM billion	168	149	151	151	151	151	3,825
Net WP saved wages	SUM billion	-	-	43	73	98	116	1,424
Net WP saved wages/yr	$ million	-	-	21	35	47	55	679

ha = hectare, income/yr = income per year WP = with project, WOP = without project, WP = with project, yr = year, wages/year = wages per year.
Source: Asian Development Bank estimates.

E. Economic Analysis

23. **Capital costs**. The project's financial base capital costs were mostly computed in US dollars and based on price quotations from foreign equipment suppliers. Those components that were originally derived in Sum were converted to economic values by making appropriate adjustments. A standard conversion factor was applied to the local currency portion of all components. Physical contingencies were then added and the prices converted into economic

prices. Cost inflation contingencies, financing charges, and import duties and taxes on inputs from foreign sources were not included at this stage.

24. Most of the total capital cost is related to the construction and rehabilitation of five pump stations and the consultancy costs of the associated management requirements. About 2.5% of the total base cost is for the rehabilitation of the main canal system, and less than 1% will go to providing facilities to develop water-saving initiatives.

25. **Implementation period.** The analysis assumed that all major works will be completed during a 6-year implementation period. The pumps were projected to become fully operational in the 7th year after the works begin.

26. **Recurrent costs**. Schedules were prepared for the without- and with-project situations. Five separate elements were identified as (i) energy costs; (ii) maintenance of pumps stations; (iii) other operation and maintenance for the ABIS; (iv) periodic pump maintenance (in the with-project situation only); and (v) the repair and/or replacement of damaged sections of discharge pipes, which is not funded under the project.

27. Under the without-project scenario that projects a complete failure of the pumps over 4 year, it is assumed that maintenance costs would decline along with the decline in the number of working pumps. Under the more conservative base case without-project scenario that assumes a gradual reduction in the pumps' operating capacity, current maintenance costs are assumed to increase by 5% annually to keep aging equipment running.

28. Current maintenance costs would rise substantially under the with-project scenario. This is because the new pumping equipment is much more sophisticated than that in use now and would require greater and better servicing than is provided to the old equipment now. At present, overall annual non-energy operation and maintenance costs for the pump stations are equivalent to about $1.2 million. With the project, they are expected to rise to around $4.5 million, exclusive of any contributions toward the capital cost of repairs and/or replacement of discharge pipes to be funded by the government.

29. The without-project situation would lead to reductions in annual energy use proportionate to the projected decline in pumping capacity as the existing equipment degrades. The with-project scenario results in an immediate drop in power consumption, beginning when the more energy-efficient new pumps become operational. The savings from lower energy use would substantially exceed the relatively small increases in maintenance costs that the new equipment would bring about. Two adjustments were made to the long-term schedule of with-project power consumption. It was assumed that the overall efficiency of the new pumps would decline slightly after 10 years of operation, with a commensurate increase in power consumption. It was also assumed that during the 3 years beginning in year 7, overall system efficiency would increase by 1.5% annually due to several improvements that the project is to introduce, including the rehabilitation of the ABIS main canal structures and the establishment of the DSS and SCADA systems (para. 1). Based on current tariffs, annual energy costs for the whole study area are now estimated to be the equivalent of about $ 81 million. Once the new pumps are installed, these costs should decline to about $64 million.

30. **Agricultural benefits.** Apart from generating energy savings, the project would prevent the potential human, social, and economic disaster that would ensue if many or most farmers in the ABIS command area lost access to irrigation water and were deprived of all agricultural production capability. Given the low rainfall patterns in the area, there is little prospect of

farmers making a living once their irrigation supply ceases as a result of a partial or complete breakdown of the ABIS's aging pump equipment. The project is projected to maintain the status quo in this respect. The analysis assumes no project-derived improvements to current levels of crop productivity. No domestic, municipal, and industrial water benefits have been included. The current net annual economic value of agricultural production from the study area is estimated to be the equivalent of $246 million.

31. In analyzing the two without-project scenarios, the analysis estimated the declines in cropped area associated with the two rates of pump capacity decline (paras. 4 and 16), and schedules of overall net income for the project area were calculated by applying crop budgets in economic prices.[10] For the with-project analysis, it was assumed that the net income would remain the same as at present after the pumps became fully operational, except in those areas currently served by pumps that would not be rehabilitated under the project.

32. Economic analysis based on the derived capital costs produced the following results for the two without-project scenarios:

(i) Under the total failure of the pump stations during year 1-4 from 2013, without-project scenario, where it was assumed that the all cropping would cease by around year 11 after project commencement, the economic internal rate of return was 20%.
(ii) Under the base case without-project scenario, where it was assumed that the operational capacity of existing pumps would gradually decline and leave only 20% of the currently cropped area in year 25 after project commencement, the economic internal rate of return was 14%.

33. Table 5 shows the results of the sensitivity analysis.

Table 5: Economic Internal Rate of Return Summary
(%)

Case	Gradual Pump Decline Scenario (Base Case)	Total Pump Failure Scenario
Base case	14.1	19.7
Sensitivity 1—10% increased capital costs	12.3	18.7
Sensitivity 2—20% increased capital cost	10.6	17.7
Sensitivity 3—3% annual decline in pumping capacity	8.5	-
Sensitivity 4—4% annual decline in pumping capacity	11.7	-
Sensitivity 5—1-year delay in onset of pump decline	12.9	-
Sensitivity 6—2-year delay in onset of pump decline	11.6	-
Sensitivity 7—3-year delay in onset of pump decline	10.1	-
Sensitivity 8—10% increase in seed cotton price	15.3	21.0
Sensitivity 9—10% reduction in seed cotton price	12.9	18.2
Sensitivity 10—energy cost of $ 0.075/kwh	12.9	17.8
Sensitivity 11—energy cost of $ 0.10/kwh	11.2	15.1

Kwh = kilowatt hours.
Source: Asian Development Bank estimates.

[10] The following were the estimated per hectare economic prices of some major crops (in good and marginal value in the 2012 crop season): cotton—SUM3,570,000 and SUM2,668,000; wheat—SUM1,892,000 and SUM1,164,000; vegetables—SUM2,608,000 and SUM1,236,000; fruit—SUM2,532,000 and SUM1,120,000; and fodder—SUM1,997,000 and SUM930,000.