ECONOMIC AND FINANCIAL ANALYSIS

I. SUBPROJECT OVERVIEW

1. The subproject has been designed with the twin objectives of irrigation rehabilitation and flood protection. It involves the rehabilitation of a nonfunctional irrigation scheme with a command area of 16,100 hectares (ha), which will also help provide flood protection to Pursat township (located further downstream from the headworks) by diverting up to 40 cubic meters per second (m^3/s) of peak river flows (more than 960 m^3/s) from the Pursat River to the Svay Donkeo River. The irrigation system is designed to accommodate increased capacity of the main canal to divert peak flood flows during the wet season, and provides for limited dry season irrigation (on average 8,000 ha based on anticipated climate change conditions) based on natural stream flow data together with options to increase drought resilience by constructing bulk storage structures.

2. The subproject includes the (i) construction of a diversion barrage across the Pursat River with an associated intake structure; (ii) rehabilitation (and in places, realignment) of an existing main canal (30 kilometers) that discharges into the Svay Donkeo River; (iii) construction of four cross regulators at the head of four secondary canals with vehicular crossings to allow for maintenance and access to markets; (iv) construction of secondary canals (with a total length of 51.5 kilometers) with associated main canal offtake structures and check structures along their length for tertiary canal offtake points (all with vehicular crossings); (v) linking with drainage structures where secondary canals join the main canal of Damnak Ampil scheme; and, (vi) construction of tertiary canals and drainage channels estimated on a per-hectare basis. The design incorporates climate resilience measures to improve water availability and reduce water demand, particularly in the dry season. Support will also be provided to the scheme operator and the farmer water users' community to assist in the management and operation of the scheme, and incremental agricultural technical support will be given to maximize the benefit from the improved supply of irrigation water in the dry season and manage the water in the wet season.

3. With the flood diversion that will be discharged into the Svay Donkeo River, and in view of the anticipated climate impacts on the frequency and intensity of annual rainfall in the area, design modifications are proposed to (i) increase the capacity of the Dhamnak Chheukrom Barrage on the Pursat River; (ii) raise the abutments, cross-regulator walls, and associated embankments on the weir at the junction of the Svay Donkeo River and Dhamnak Ampil main canal; and, (iii) raise the abutments and associated embankments on the Anlong Svay weir on the Svay Donkeo River. To improve drought resilience, incremental investments will be made to strengthen the impounding embankment surrounding the Phteah Rung Reservoir and provide new field reservoirs within the tertiary and distribution areas that will retain wet season runoff for dry season irrigated production.

II. METHODOLOGY

4. Only quantifiable and significant benefits and costs are examined to assess subproject viability and to understand the anticipated impact on the economy and society as a whole. Costs and benefits are calculated under two alternative scenarios: the "with-subproject" scenario and the "without-subproject" scenario. Benefits have been quantified from incremental agricultural output. Benefits from reduced flood damage to commercial activities and public infrastructure, and the cost of relocating families around Pursat township have been estimated based on data provided by the National Committee for Disaster Management based on the 2000 and 2011

floods and extrapolating the extent of damage to higher and lower frequency return periods of flood. The command area[1] is examined under both scenarios, based on the full irrigated area after rehabilitation of delivery canals and water management structures. In the without-subproject scenario this command area is assumed to receive only natural rainfall in the wet season without supplementary irrigation, and no dry season irrigation. The with-subproject scenario assumes finishing water is applied to the medium- and late-maturing wet season paddy crops over the entire rehabilitated command area. The additional water during the dry season will enable an incremental area of about 8,000 ha on average. The analysis takes into account what might be produced on this land without the proposed development. The intent is to identify the incremental value of production and losses prevented that can be attributed to subproject investment over its expected economic life, and compare this value to the cost of implementing the subproject and operating and maintaining the rehabilitated or new infrastructure.

5. To develop a model for the analysis, the following assumptions are made regarding future farming practice (both with and without the subprojects) and the increased water made available for dry season irrigation:

(i) Subproject life is 25 years; i.e., assuming adequate maintenance, the irrigation system should be able to maintain its expected benefits for 25 years before another major renovation is required.
(ii) Without the subproject, existing cultivation patterns and technology are expected to continue for the life of the subproject.
(iii) With the subproject, the command area is expected to receive supplementary irrigation throughout the effective life of the subproject, allowing farmers to adopt higher value cropping patterns and technology as appropriate.
(iv) Some agricultural outputs may be consumed within the household, but these are valued as if sold.
(v) Some agricultural inputs, such as farm labor, are provided by the farming household but are valued at the market rate as if hired.
(vi) To exclude inflation, output values are expressed in constant 2011 terms.
(vii) Costs are expressed in constant 2011 riels (local costs) and constant 2011 US dollars (foreign currency costs). Future price predictions in current terms are adjusted to constant 2011 terms using the Manufactures Unit Value Index as published by the World Bank.[2]
(viii) The Cambodian riel is the unit of currency. The exchange rate used for any conversions necessary is the mid-year rate with the US dollar.
(ix) Future production on the command areas is estimated based on historic achievements but modified post-subproject to reflect the improved water management and reduced flooding resulting from the investment.
(x) Dry season irrigation is incorporated on the assumption that the upstream hydropower dam is not constructed. In the event that the upstream hydropower dam is constructed, the area for dry season irrigation will increase, improving the economic internal rate of return (EIRR).

[1] The command area is that area that can be efficiently irrigated from the rehabilitated canal and water management structures. Where rehabilitation is the dominant activity - the command area often remains the same in the with and without the subproject scenarii whereas in the case of extension into new areas, the command area will increase in addition to the improved productivity on the established irrigated area.

[2] World Bank. Manufactures Unit Value Index. http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/ EXTDECPROSPECTS/0,,contentMDK:20587651~menu%20PK:3279864~pagePK:64165401~piPK:64165026~theSitePK:476883,00.html

6. Financial prices used in this analysis were identified through field visits during the preparation studies. These prices have been cross-checked with prices identified in other projects and secondary sources including the Rice Value Chain Study for Cambodia.[3]

7. To assess subproject contributions to the economy of Cambodia, financial values have been converted to economic equivalents. Economic valuations exclude transfers from one part of society to another (i.e., taxes, subsidies, and compensation costs) and attempt to facilitate the comparison of subproject benefits and real opportunity costs to the economy by translating all prices into a common, undistorted footing. Basic assumptions (in addition to those in para. 5) used in the economic analysis include the following:

(i) A domestic price numeraire is used.
(ii) In the case of major tradable commodities (food grains and fertilizers), economic values are based on border parity prices.
(iii) For nontraded goods and services, a standard conversion factor of 0.9 is used. For rural labor, a shadow wage rate factor of 0.85 is applied, which reflects the productivity of rural labor in the area.
(iv) Transfer payments such as taxes, subsidies, and compensation are excluded in the calculation of economic values. The administration cost of compensation is included.
(v) To calculate the economic net present value (NPV) of the subproject, a discount rate of 12% is used to represent the opportunity cost of capital invested.

A. Subproject Benefits

8. Incremental benefits were derived from the introduction of double cropping on 8,000 ha of previously wet season cropped areas and from incremental production associated with supplementary irrigation. Rice yields adopted in the analysis reflect actual yields achieved under existing production technologies for the without-subproject scenario. With the improved water management in the wet season and the introduction of superior production technologies, wet season rice yields are anticipated to increase from 2.7 tons/ha in 2012 to 4.0 tons/ha by 2015. Dry season yields are estimated to be 4.5 tons/ha as soon as irrigation water is available. There is no dry season rice production without the subproject. In assessing the potential command area, it has been assumed that 73% of the agricultural area will be serviced by the rehabilitated irrigation system. For dry season irrigation, it is estimated that some 8,000 ha can be double-cropped of the potential command area of 16,100 ha for dry season production while for wet season production, the full command area will benefit.

9. Three crop models are applied to the various areas with and without the subproject. Wet season rice production with existing technologies is compared to the with-subproject scenario of wet season production on the full 16,100 ha plus incremental production from an irrigated dry season crop on 8,000 ha. Production was valued at derived farm gate prices in economic terms (Appendix 1) to generate incremental net values of production. Incremental net benefits were then compared to subproject capital and operating costs in economic terms to arrive at a net revenue benefit stream that was used to assess the viability of the investment.

---

[3] Agrifood Consulting International. 2010. *Rice Value Chain Study: Cambodia.* Report Prepared for the World Bank. Phnom Penh, Cambodia.

10. Flood benefits to Pursat township have been estimated based on actual flood damage figures from the 2011 flood damage reports. Damage reports submitted to the National Disaster Management Committee from Pursat Governor's Office were assessed in 2011 values and the frequency of the extent of flooding was determined to be a 1 in 10 year flood. Damage estimates were extrapolated for return periods of 1 in 5, 1 in 20, and 1 in 50 years using an "S" curve. The average annual damage was then estimated by using these damage estimates and the probability of the area receiving such a flood event. Estimated in this way, the average annual flood damage saving was estimated to be $1.5 million a year in economic terms (Appendix 2)

B. Economic Analysis

11. The economic analysis compares the identified net incremental benefits attributed to the investment with the costs of developing the irrigation system. Based on the models developed, the EIRR for the subproject is 12.1% and the NPV evaluated at 12% is $0.14 million. The EIRR suggests that this investment will justify the commitment of public funds as it can be anticipated to return benefits around the opportunity cost of capital (estimated at 12%). The incremental benefits attributed to irrigation rehabilitation of the 16,100 ha (including wet and dry season production) is estimated at $3.89 million per annum at full production (given other assumptions) while the annual flood benefit is estimated at $1.5 million per annum.

12. Sensitivity analyses were undertaken for the subproject based on the perceived risks. These included construction cost escalation, reduced command area achieved, reduction in the dry season irrigated area, reduction in the flood benefit, and reduction in the price of rice—all at 10% and 20% variations around the base-case scenario (rice price was the exception, with declines of 5% and 10%, due to the relative sensitivity to this variable). Switching values were calculated by comparing the change in EIRRs in response to each of the imposed risk factors.

13. As rice production is the sole crop benefit, it is not surprising that the EIRR and NPV estimates are sensitive to international rice price fluctuations. Current price levels are high, although they are significantly below their peak in 2010 when the international rice shortage was experienced. While prices remain reasonably high, the longer-term prospects for rice as presented in World Bank's commodity outlook publications are below the current levels. Whether projected levels are realized is speculative. However, it is clear that the models developed to assess the impact of the investment are sensitive to rice price fluctuations. For example, a reduction of 5% in the price of rice in all years of the evaluation will result in a decline of the EIRR to 9.3%, while a 10% reduction will result in the EIRR estimate declining to 6.2%—both figures that are far below the accepted cost of capital. However, in view of the shift that is taking place in the main exporting countries away from rice production into higher value crops, there is some confidence that price levels will not be reduced much beyond their current levels in the immediate future. For this reason, the risk of a price decline is considered small. Therefore even though the model adopted is sensitive to price fluctuations, the risk is considered to be relatively low.

14. The second potential area of risk assessed is the command area estimates. During the detailed design phase, a comprehensive topographic survey will be conducted. The command area that can be achieved from an irrigation investment usually has a strong influence on the profitability of the investment for obvious reasons (particularly in this case where the main canal is already overdesigned to accommodate a flood mitigation function). The EIRR was tested against reductions of 10% and 20% of the achieved command area. These reductions caused

small decreases in the overall profitability of the investment—to 9.8% for a 10% reduction and 7.4% for a 20% reduction.

15. The other variable to which the model is highly sensitive is the area of dry season irrigation achieved. As current levels of dry season production are zero, a significant proportion of overall benefit is derived from dry season rice production (as 50% is assumed based on the probability of the levels of annual rainfall). This is a function not only of the irrigated or effective command area but also of the availability of water for irrigation. Under the existing dry season flows, there is potential for some 8,000 ha of dry season production. With the proposed hydroelectric dam, dry season flows will become more assured and it should be possible to grow irrigated rice on the full command area. This analysis is conservative, and assumes that the dam is not constructed. Current estimates suggest there is adequate water for at least the initial 16,100 ha command area during the wet season to ensure water in the critical periods when needed (at flowering). The model is sensitive to reductions in the achieved dry season irrigated area: with a 10% reduction the resultant EIRR declines to 11.2%, and with a 20% reduction it declines to 10.3%. It will be important to ensure that the largest possible area can be irrigated during the dry season to ensure viability of the investment. To improve drought resilience, incremental investments will be made to strengthen the impounding embankment surrounding the Phteah Rung Reservoir and provide new field reservoirs within the tertiary and distribution areas that will retain wet season runoff for dry season irrigated production.

16. Sensitivities due to variations in the overall flood benefit are more difficult to assess. Given the unpredictable nature of flooding, overall profitability could change dramatically in one season if extreme flooding were diverted from Pursat township. The river breaches its banks in Pursat township at flow rates over 1,000 m^3/s. While 40 m^3/s can be diverted along the main canal during periods of peak flow, this would appear to be a relatively small volume compared to the actual river flow. However, the removal of an incremental level once the river is at peak flow is considered a significant contribution to the reduction of flood damage. Variation of 10% in the level of flood damage avoided result in an EIRR of 11.3%, while a variation of 20% yields an EIRR of 10.5%.

17. The final risk area is the escalation of capital costs for the development. The model is quite sensitive to such variation with a 10% increase generating an EIRR of 10.2% and a 20% increase giving an EIRR of 8.6%. Since benefits from incremental rice production are a key driving factor of the EIRR, the level of vulnerability is relatively high given the current outlook for rice prices. As rice is a staple crop of the area and geographic shortages for immediate consumption are still common in northwest Cambodia, the investment is considered a reasonable risk.

Appendix 1: Farm Gate Economic Price Derivation for Internationally Traded Rice

(2011 Constant Cambodian Riel – [KHR])		**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Rice paddy: (Export parity in 2011 currencies)[a]											
Thailand (current $)[a]	$/t	480	478	475	473	470	466	462	458	454	450
Thailand (constant 2000 $)[a]	$/t	394	391	386	381	378	373	368	363	358	353
MUV (2000=1.00)	2000	1.22	1.22	1.23	1.24	1.24	1.25	1.26	1.26	1.27	1.27
MUV (2011=1.00)	2011	1.00	1.00	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.05
Rice FOB Bankok (constant 2011 $)	$/t	480	476	470	465	461	454	448	442	436	430
Quality Adjustment[b]	$/t	384	381	376	372	368	364	359	354	349	344
Freight, insurance, etc.	$/t	20	20	20	20	20	20	20	20	20	20
CIF Kampong Som	$/t	364	361	356	352	348	344	339	334	329	324
CIF Kampong Som in KHR[c]	KHR '000/t	1,485	1,473	1,453	1,435	1,421	1,402	1,382	1,362	1,342	1,322
Freight and handling K.Som to Pursat[d]	KHR '000/t	76	76	76	76	76	76	76	76	76	76
Conversion to paddy[e]	KHR '000/t	845	838	826	815	807	795	783	772	760	748
Milling charges net of bran value	KHR '000/t	14	14	14	14	14	14	14	14	14	14
Handling and transport farm to mill[d]	KHR '000/t	17	17	17	17	17	17	17	17	17	17
Economic Farmgate Price per tonne	KHR '000/t	814	807	795	784	776	764	752	740	728	716
Economic Farmgate Price per kg	KHR/kg	814	807	795	784	776	764	752	740	728	716

CIF = Cost, Insurance and Freight, FOB = Free on Board, MUV = Manufacture Unit Value Index.
Note: Similar price derivations have been completed for traded fertilizers: diammonium phosphate, urea and triple superphosphate.
[a] World Bank Commodity Price Projections prepared November, 2010 for 2011, 2012, 2015 and 2020 with other years interpolated. (Thailand, 5% broken, white rice, milled, FOB Bangkok)
[b] Adjustment for Quality = 20%.
[c] Exchange rate of Cambodian Riel per $ in May 2011 = 4,080.
[d] Standard conversion factor applied on half the amount of handling, transportation and milling = 90%.
[e] Conversion factor of paddy to rice = 60%
Source: Asian Development Bank

Appendix 2: Flood Benefits

A. Data on Damage from Flooding in 2011 (provided by Pursat Governor's Office to the National Committee for Disaster Management)—assumed to be a 1 in 20 year flood

City/County	Flood Affected Villages	Population Displaced (families)	Agricultural Land (‘000 ha)	Rice Production (‘000 tons)	Rice Output ($ million)	Industrial Output ($ million)	Industrial Assets ($ million)	Public Infrastructure ($ million)	Household Assets ($ million/yr)
Bakan District	47	670	11.778	29.45	5.99	0.00	0.00	0.75	0.06
Kandieng District	54	411	3.116	7.79	1.59	0.00	0.00	0.48	0.16
Krakor District	35	510	2.942	7.36	1.50	0.00	0.00	0.27	0.00
Pursat Township	7	400	1.000	2.50	0.51	1.00	0.00	0.74	0.30
Total	**143**	**1991**	**18.836**	**47.09**	**9.58**	**1.00**	**0.00**	**2.24**	**0.52**

B. Damage Estimates - Economic

Flood Frequency	Population Evacuation ($ million/yr)	Agricultural Output ($ million/yr)	Industrial Output ($ million/yr)	Industrial Assets ($ million/yr)	Public Infrastructure ($ million/yr)	Household Assets ($ million/yr)	Total ($ million/yr)
20%	0.00	0.8	0.3	0.0	0.3	0.1	1.5
10%	0.04	2.8	0.9	0.0	1.0	0.4	5.2
5%	0.20	2.8	0.9	0.0	1.0	0.4	5.2
2%	0.60	11.3	3.4	0.0	4.1	1.8	20.6

Source: Asian Development Bank