ECONOMIC ANALYSIS

A. Economic Rationale

1. Climate-induced changes to the Mekong River and its tributaries will adversely affect wetland ecosystems, such as the Tonle Sap, which is the largest freshwater lake in Southeast Asia. About 20% of the Mekong River's floodwaters are absorbed by the Tonle Sap, with 62% of the Tonle Sap's water originating in the Mekong River and 38% in the Tonle Sap basin. The Tonle Sap is connected to the Mekong River by the 100-kilometer (km) Tonle Sap River, which reverses its flow seasonally. Average water levels in the Tonle Sap may increase by 0.2 meters (m) and peak water levels may increase by up to 0.3 m by 2050, so flood durations may be 9% longer under anticipated climate change conditions and the probability of river floods is likely to increase.[1]

2. Urban areas are crucial to Cambodia's development and its integration into regional markets such as the Greater Mekong Subregion (GMS) and the Association of Southeast Asian Nations (ASEAN). Urban areas around the Tonle Sap like Kampong Chhnang and Pursat are key economic growth centers. They have direct and symbiotic relationships with their rural areas, which are based on agriculture, fisheries, and manufacture. Increased prosperity in urban areas and greater climate-resilient infrastructure will strengthen rural–urban linkages.

3. The Tonle Sap Urban Areas Development Framework (TSUADF) guides sustainable growth and climate-resilient infrastructure development of urban areas in the Tonle Sap Basin. It seeks to protect the Tonle Sap ecosystems from environmental pollution and unregulated growth and urbanization through an agreed vision and approach. It prioritizes Kampong Chhnang and Pursat municipalities for urban planning and investments because of their strategic (location and economic) importance, climate change risk and environment protection needs, and synergies with Asian Development Bank (ADB) projects on agriculture and rural development.

4. Kampong Chhnang and Pursat government agencies listed poor environmental sanitation as their towns' biggest infrastructure issue. Lack of climate-resilient infrastructure, especially around the Tonle Sap, leaves residents vulnerable to flooding and climate-induced disasters. Limited solid waste collection and poor management is a major environmental issue in flood-prone areas of the Tonle Sap and a health concern for communities. The embankment in Kampong Chhnang, for instance, is imperative for residents to have continued access to social services and economic activities (e.g., rice processing mills) in the town area. Improved flood protection will assist farmers in the eastern part of the municipality to increase agricultural production from two to three crops per year.[2] The town drainage will improve and strengthen the storm water drainage system to accommodate more intensive rainfall. It will support increased economic activities in the town (e.g., marble process and carvings), and facilitate residents' continued access to social services.[3]

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[1] C.T. Hoanh et al. 2010. Impacts of climate change and development on Mekong flow regime. First assessment–2009. *MRC Technical Paper No. 29 (June)*. Vientiane: Mekong River Commission; and K. Västilä et al. 2010. Modeling Climate Change Impacts on the Flood Pulse in the Lower Mekong Floodplains. *Journal of Water and Climate Change*. 1(1). pp. 67–86.

[2] Output 1 complements the Japan International Cooperation Agency drainage project in Kampong Chhnang and German development cooperation through Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) support for development of the urban master plans.

[3] Output 2 complements the GMS Flood and Drought Risk Management and Mitigation Project, which provides support to the Dhamnak Choeukrom Irrigation System Rehabilitation (located about 40 km upstream). ADB. 2012. *Report and Recommendations of the President to the Board of Directors: Proposed Loan and Administration of*

5. The private sector is not involved in public works infrastructure and services on flood management and drainage because of the nature of the assets, potential for revenue and profit, and type of public services. The net benefits generated from these services will spill over to a broader segment of society that helps justify some form of public subsidy for capital investments (e.g., drainage and sanitation). In addition, limited private sector participation in solid waste management (SWM) has resulted in the need for the government to take a greater role in, and ownership of, collection and management services in order to avoid jeopardizing towns' economic prospects and activities and people's welfare. The project will explore private sector involvement. Where private sector interest is found, the project will help strengthen the government's ability to develop and manage these contracts.

B. Methodology

6. The economic analyses of the subprojects were conducted in accordance with ADB's *Guidelines for the Economic Analysis of Projects,* and *Handbook for Integrating Risk Analysis in the Economic Analysis of Projects.*[4]

7. In each subproject, only one option was technically viable.[5] Benefits and costs were arrived at through comparison of the with- and without-project conditions. Benefits and costs were estimated over each subproject's estimated economic life at constant 2015 prices. An average exchange rate of KR4,115 = $1.00 was used in the analysis. Annual benefits and costs for each subproject were evaluated up to 2045, allowing for 5-year construction period starting in 2016, followed by a benefit period of 25 years. All costs were valued using the domestic price numeraire. Economic costs were derived from the technical team's financial estimates of capital and operation and maintenance (O&M) costs, and adjusted for transfer payments and any other market distortions. Taxes and duties were excluded because they represent transfer payments. Traded goods, net of taxes and duties, were adjusted by a shadow exchange rate factor of 1.10 while a factor of 1.0 was applied for non-traded goods and skilled labor. A shadow wage rate factor of 0.75 was used for unskilled labor. These parameters are consistent with those used in recently approved ADB-financed project in Cambodia.[6] The economic value of land acquired was estimated based on its net economic benefit over the life of the project.[7] An economic opportunity cost of capital (EOCC) of 12% was assumed for the analysis.

C. Economic Analysis

1. Drainage and Flood Protection

8. For the flood control subproject in Kampong Chhnang, the benefits were derived mainly from (i) savings in household property damages avoided, and (ii) income from recovered agricultural and industrial land. In Pursat, a combined economic analysis was conducted because

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Loan and Grants to the Kingdom of Cambodia for the Greater Mekong Subregion Flood and Drought Risk Management and Mitigation Project. Manila.

[4] ADB. 1997. *Guidelines for the Economic Analysis of Projects*. Manila; ADB. 2002. *Handbook for Integrating Risk Analysis in the Economic Analysis of Projects*. Manila.

[5] Technical Feasibility for Kampong Chhnang Flood Protection, Technical Feasibility for Pursat Drainage and Embankment, Technical Feasibility for Kampong Chhnang Solid Waste Management, and Technical Feasibility for Pursat Solid Waste Management (available from the list of linked documents in Appendix 2).

[6] ADB. 2012. *Report and Recommendations of the President to the Board of Directors: Proposed Loan and Administration of Loan and Grants to the Kingdom of Cambodia for the Greater Mekong Subregion Southern Economic Corridor Towns Development Project.* Manila.

[7] The rice crop budget model was used in the estimation of net economic benefit. Net economic benefits were $778 each year for KCH and $1,156 each year for Pursat during the project.

of the difficulty of delineating the areas to benefit from the proposed drainage and river embankment subprojects, as both prevent flooding. The economic benefits were calculated by quantifying (i) savings from household property damages avoided, and (ii) savings from the agricultural and commercial losses averted.

9. **Kampong Chhnang flood protection**. Town officials indicated that about 1,882 households were heavily affected by annual flooding while about 1,255 households were moderately affected. Town officials estimated the average annual costs of repairs and cleaning since 2010 at $250 per household for those heavily affected and $50 per household for those moderately affected, stated in economic prices.

10. With the flood protection improvements, about 720 hectares (ha) of agricultural land and about 705 ha of industrial land would be recovered as a result of the subproject. Benefits from the recovered agricultural land were valued in terms of income from rice farming of the recovered land. Income from rice farming was calculated based on three crop harvests each year. Average yields per hectare were assumed at 4 tons in the dry season, 4 tons in the early wet season, and 3 tons in the wet season. Net economic revenues each year, calculated based on a rice crop budget model,[8] were estimated at $233,000 in the dry season, $191,000 in the early wet season, and $212,000 in the wet season. The economic unit prices of output and inputs used in the rice crop budget model were based on a recently approved ADB project in Cambodia involving rice.[9]

11. The benefits from the 705 ha recovered industrial land were estimated at $4,935,000 each year, quantified in terms of the prevailing average monthly lease fee estimated at $583 per hectare, stated in economic prices.

12. **Pursat flood protection**. Town officials indicated that about 980 households were heavily affected by annual flooding while about 245 households were moderately affected. Town officials estimated the average annual costs of repairs and cleaning since 2010 at $250 per household for those heavily affected and $50 per household for those moderately affected, stated in economic prices.

13. With the flood protection improvements, agricultural and commercial losses would be averted. Avoided agricultural losses were derived based on the following assumptions: (i) average yield per hectare at 3.5 tons of rice; (ii) 2,376 ha heavily affected with harvest completely destroyed; and (iii) 5,544 ha moderately affected with harvest reduced by about 50%. The avoided net economic losses each year, calculated based on a rice crop budget model, were estimated at $701,000 in the areas heavily affected and $818,000 in the areas moderately affected. The economic unit prices of output and inputs used were the same as in Kampong Chhnang.

14. Avoided commercial losses from the public market's temporary closure as a result of flooding were assumed at 10% of the projected annual net economic revenues of the various business establishments involved. Revenues of the various business establishments involved were estimated based on the data provided by town officials.

15. **Evaluation results**. The resulting base case EIRR of 18.22% for Kampong Chhnang and 16.88% for Pursat are higher than ADB's 12% EOCC. This demonstrates the economic contribution of the proposed subprojects to the towns and communities. Sensitivity analysis

[8] Complete Economic and Financial Analysis (available from the list of linked documents in Appendix 2).

[9] ADB. 2013. *Report and Recommendation of the President to the Board of Directors: Proposed Loans and Administration of Grants and Loan to the Kingdom of Cambodia for the Climate-Resilient Rice Commercialization Sector Development Program.* Manila.

suggests that the EIRRs will be more vulnerable to changes in the anticipated benefits from the subprojects. Capital costs will have to increase by 33.3%–40.2%, while benefits will require only a reduction of 25.2%–35.7% for the EIRRs to drop to the EOCC (Table).

2. Solid Waste Management

16. The economic benefits quantified for the SWM subprojects in both towns were reduced health risks from poor SWM as measured through a reduction in disability-adjusted life years (DALYs).[10] It was observed that the lack of proper SWM in both project towns prompted many households to burn their trash—one of the major causes of outdoor pollution in developing countries. Likewise, residents indiscriminately dispose of their solid wastes anywhere such as public roads, drains, house yards, vacant land plots, Tonle Sap River, and the banks—clogging the drainage systems and polluting the water.

17. The World Health Organization (WHO) estimated the total DALYs of Cambodia at 38,451 per 100,000 population.[11] The WHO also estimated that 10% of the total DALYs of Cambodia were related to water, sanitation, and hygiene;[12] and 1.3% were attributable to outdoor air pollution.[13] The economic analysis assumes that 1% of the total DALYs in each town are caused by poor SWM. As a result of the subprojects, the DALYs attributable to poor SWM in each town are assumed to reduce by 75%.

18. The approach of the WHO in calculating the annual economic value of a DALY to be equivalent to a country's gross national income (GNI) per capita was adopted.[14] Cambodia's estimated GNI per capita in 2012 was $2,690.[15] The analysis conservatively assumes GNI per capita growth of 2% per annum.

19. **Evaluation results**. The resulting base case EIRRs of 16.64% for Kampong Chhnang and 14.50% for Pursat are higher than ADB's 12% EOCC. This demonstrates the economic contribution of the proposed subprojects to the towns and communities. Sensitivity analysis suggests that the EIRRs will be more vulnerable to changes in the anticipated benefits from the subprojects. Capital costs will have to increase by 12.7%–27.1%, while benefits will require only a reduction of 10.0%–13.8% for the EIRRs to drop to the EOCC (Table).

[10] A DALY is an indicator of life expectancy combining mortality and morbidity in one summary measure of population health to account for the number of years lived in less than optimum health. The approach was developed by Harvard University for the World Bank in 1990 for a study that provided a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors. The World Health Organization (WHO) adopted the method in 1996. DALY determination is continually revised by the WHO.

[11] World Health Organization. 2004. World Health Report. Geneva.

[12] WHO. 2007. Environmental Burden of Disease Series No. 15 (Water, Sanitation and Hygiene). Geneva.

[13] WHO. 2004. Environmental Burden of Disease Series No. 5 (Outdoor Air Pollution). Geneva.

[14] The WHO Commission on Macroeconomics and Health assumes that each DALY can be valued at 1 year of per capita GNI to arrive at a conservative estimate of the economic value of a DALY.

[15] World Bank. 2012. World Development Indicators. Washington, DC.

Table: Economic Evaluation of Subprojects ($'000)

	KCH Flood Protection						KCH SWM				PST Flood Protection						PST SWM			
Year	Capital Costs	O&M Costs	HH Property Damages	Agricultural Land Net Revenue	Industrial Land Lease Fee	Net Benefits	Capital Costs	O&M Costs	DALYs	Net Benefits	Capital Costs	O&M Costs	HH Property Damages	Agricultural Losses	Business Losses	Net Benefits	Capital Costs	O&M Costs	DALYs	Net Benefits
2015																				
2016	1,413					(1,413)	203			(203)	590					(590)	306			(306)
2017	4,219					(4,219)	914			(914)	1,743					(1,743)	1,376			(1,376)
2018	11,252					(11,252)	711			(711)	4,649					(4,649)	1,071			(1,071)
2019	8,439					(8,439)	203	308	517	6	3,487					(3,487)	306			(306)
2020	2,813	134	533	637	4,935	3,158		308	537	229	1,162	444	257	1,519	942	1,111		439	745	306
2021		134	533	637	4,935	5,971		308	567	259		444	257	1,519	942	2,274		439	779	340
2022		134	533	637	4,935	5,971		308	597	289		444	257	1,519	942	2,274		439	815	376
2023		134	533	637	4,935	5,971		308	629	321		444	257	1,519	942	2,274		439	852	413
2024		134	533	637	4,935	5,971		308	661	353		444	257	1,519	942	2,274		439	890	451
2025		134	533	637	4,935	5,971		308	694	386		444	257	1,519	942	2,274		439	931	492
2026		134	533	637	4,935	5,971		308	719	410		444	257	1,519	942	2,274		439	973	535
2027		134	533	637	4,935	5,971		308	744	436		444	257	1,519	942	2,274		439	1,017	579
2028		134	533	637	4,935	5,971		308	771	462		444	257	1,519	942	2,274		439	1,064	625
2029		134	533	637	4,935	5,971		308	798	490		444	257	1,519	942	2,274		439	1,112	673
2030		134	533	637	4,935	5,971		308	878	570		444	257	1,519	942	2,274		439	1,162	723
2031		134	533	637	4,935	5,971		308	907	599		444	257	1,519	942	2,274		439	1,214	775
2032		134	533	637	4,935	5,971		308	938	630		444	257	1,519	942	2,274		439	1,269	830
2033		134	533	637	4,935	5,971		308	968	660		444	257	1,519	942	2,274		439	1,324	886
2034		134	533	637	4,935	5,971		308	1,001	692		444	257	1,519	942	2,274		439	1,380	941
2035		134	533	637	4,935	5,971		308	1,034	726		444	257	1,519	942	2,274		439	1,438	999
2036		134	533	637	4,935	5,971		308	1,068	760		444	257	1,519	942	2,274		439	1,495	1,056
2037		134	533	637	4,935	5,971		308	1,099	791		444	257	1,519	942	2,274		439	1,555	1,116
2038		134	533	637	4,935	5,971		308	1,135	827		444	257	1,519	942	2,274		439	1,614	1,175
2039		134	533	637	4,935	5,971		308	1,171	863		444	257	1,519	942	2,274		439	1,675	1,236
2040		134	533	637	4,935	5,971		308	1,207	899		444	257	1,519	942	2,274		439	1,735	1,296
2041		134	533	637	4,935	5,971		308	1,244	935		444	257	1,519	942	2,274		439	1,796	1,357
2042		134	533	637	4,935	5,971		308	1,280	972		444	257	1,519	942	2,274		439	1,858	1,420
2043		134	533	637	4,935	5,971		308	1,319	1,011		444	257	1,519	942	2,274		439	1,919	1,481
2044		134	533	637	4,935	5,971		308	1,360	1,052		444	257	1,519	942	2,274		439	1,981	1,542
2045		134	533	637	4,935	5,971		308	1,400	1,092		444	257	1,519	942	2,274		439	2,044	1,605
			EIRR	**NPV**	**SV**	**SI**	**EIRR**	**NPV**	**SV**	**SI**		**EIRR**	**NPV**	**SV**	**SI**		**EIRR**	**NPV**	**SV**	**SI**
Base Case			18.22%	9,257			16.64%	760				16.88%	2,953				14.50%	637		
Case 1: 10% increase in capital costs			16.67%	7,507	40.2	2.5	13.00%	192	12.7	7.9		15.41%	2,230	33.3	3.0		13.58%	429	27.1	3.7
Case 2: 10% increase in O&M costs			18.19%	9,202	1,921.4	0.1	13.04%	188	12.9	7.8		16.61%	2,774	180.6	0.6		13.82%	460	36.8	2.7
Case 3: 10% decrease in benefits			16.48%	6,521	35.7	2.8	12.02%	3	10.0	10.0		14.94%	1,735	25.2	4.0		12.69%	169	13.8	7.2
Case 4: Cases 1, 2 and 3 combined			15.00%	4,712			10.44%	(290)				13.28%	813				11.10%	(235)		
Case 5: delay in benefits by 1 year			15.77%	6,163			12.30%	57				14.35%	1,576				12.30%	81		

( ) = negative, DALY = disability adjusted life year, EIRR = economic internal rate of return, HH = household, KCH = Kampong Chhnang, NPV = net present value, O&M = operation and maintenance, PST = Pursat, SI = sensitivity indicator, SV = switching value, SWM = solid waste management.
Source: Asian Development Bank.