I. Background

1. Thailand is one of the 16 countries identified globally as being in the 'extreme risk' category of those most vulnerable to future climate change impacts over the next 30 years.[1] The main impacts due to climate change in Thailand being related to droughts and floods.[2] Extreme, severe drought and flood are likely to be experienced increasingly in the near and longer-term future, as a result of the combined effects of a more vigorous hydrological cycle, combined with enhanced surface drying due both to anthropocentric climate change and the anomalous oscillations of ENSO.[3] Climate change is expected to increase both the magnitude and frequency of extreme precipitation events, leading to more intense and frequent flood events. At the same time, Thailand has already experienced increases in temperatures, with an overall decrease in the number of days of rain, and an increase in the daily rainfall intensity.[4]

2. When modeled by Conformal Cubic Atmospheric Model (CCAM) under IPCC SRES scenario A1FI, the average temperature is expected to increase by 1-2°C. Statistical downscaling from the GCM GFL-R30 under B2 scenario for the project area indicates the temperature increase to be approximately 1°C for 2040 – 2059. However, dynamical downscaling from MM5-Regional Climate Model by using CCSM3 indicates that during 2010-2039 under SRES A1B scenario, summer temperatures over Thailand are projected to increase by 0.1-0.6°C. Similarly, in the ensemble study it was shown that compared to the average during 1980-1989, the average temperature during 2040-2059 will increase by 1-2°C, especially during the summer months the temperature would increase by 3-5°C. The annual average daily mean temperature and precipitation from the downscaling of GCM-GFDL-ESM2M GCM-MPI-ESM-LR and GCM-HadGEM2-ES under 3 CMIP5-RCPs scenarios, including RCP4.5, 6.0 and 8.5 indicates that average daily mean temperature for the whole country area show an increase under RCP4.5, 6.0 and 8.5 scenario conditions in all GCMs except the RCP4.5 of GCM-GFDL-ESM2M. Annual average daily mean temperature change for the end of 21st century over the area of Thailand is to exceed 2°C relative to the 1951-2011 long term average for all GCMs and RCP scenario except GCM-GFDL-ESM2M. Increase of mean temperature in 2100 for GCM-GFDL-ESM2M, GCM-MPI-ESM-LR and GCM-HadGEM2-ES under RCP8.5 scenario of these three GCMs relative to 1951-2011 is projected to be 1.7°C, 4.0°C and 4.8°C.

3. In the results from downscaling from ECHAM4 GCM using PRECIS, projections are that precipitation will increase over the whole country under both A2 and B2 scenarios. The length of rainy season will be likely similar to the present (2016), indicating the rainfall intensity will be increased. Already high precipitation in some areas (e.g. the southern peninsula) is set to see heavier rainfalls, while other areas with lower precipitation levels expected to decline to even lower amounts (inland and northeastern region).

4. The overall purpose of the proposed investment project is to mitigate the impacts of the projected intensification of floods and drought in the not so distant future.

5. This annex describes and presents the results of the economic analysis of the proposed investment project and associated outputs and activities. We have quantified and/or monetized benefits where possible, and we also describe qualitatively the value of the project activities when quantitative benefits data are not available. Some project activities (such as capacity building and research) will focus on

[1] Intended Nationally Determined Contribution (INDC) for Thailand http://www4.unfccc.int/ndcregistry/PublishedDocuments/Thailand%20First/Thailand_INDC.pdf
[2] Thampanishvong, K. 2014, *Farmers' Adaptation to Extreme Weather Events in the Chao Phraya River Basin*, Thailand Development Research Institute, October 15 2014
[3] Limsakul, A., Chidthaisong, A. and Boonpragob, K. 2011, *Thailand's First Assessment Report on Climate Change: Working Group I-Scientific Basis of Climate Change*, Thailand Research Fund.
[4] Intended Nationally Determined Contribution (INDC) for Thailand, 2015: http://www4.unfccc.int/ndcregistry/PublishedDocuments/Thailand%20First/Thailand_INDC.pdf

protecting investments made under other activities, contributing to long-term delivery of benefits and reducing the need for investments in the future.

II. Approach and Methodology

6. The economic analysis of the proposed project was carried out in accordance with the *Guidelines for the Economic Analysis of Projects of United Nations Development Program*.[5] The economic efficiency of the investment was determined by computing the economic net present value (NPV) with an assumed 10% discount rate, and the economic internal rate of return (IRR). For consistency purposes, all proposals developed with the support of UNDP have opted to use a 10% discount rate, in line with the existing practice of multilateral development banks.

7. Economic values (costs and benefits) are all measured in real terms of 2019. Economic costs of the project are net of taxes, duties, and price contingencies. Furthermore, the analysis assumes a shadow wage rate of 1.00 for unskilled and semi-skilled labour in Thailand. With an official unemployment rate estimated at less than 1.5%, this assumption is appropriate. Provided that the economic cost of labour in Thailand may be expected to be lower than the market wage rate (financial cost), we expect this assumption leads to significantly over-estimating the economic cost of the project, and under-estimating the true net economic value of the project.[6]

8. For purpose of the economic analysis, it is assumed that the capital assets have an average longevity of 20 years. Since, capital investment is expected to have been completed in 2024, it is assumed that this 20-year time horizon covers the period 2025 to 2044. Hence, the entire period of analysis covers the period 2020 to 2044.

9. As is common when undertaking the economic analysis of investment projects, numerous assumptions were used to delineate the “with project scenario” from the “without project scenario”. These assumptions are presented and discussed in details below. Assumptions were always made so as to under-estimate the true net economic value of the proposed investment project.

III. Economic Costs

10. This section of the economic analysis presents the treatment of the economic cost of the project across outputs and across years, starting with the capital cost (III.1), and then of the operation and maintenance costs.

III.1 Capital cost

11. As indicated in the proposal, the project comprises 4 outputs, inclusive of project management. These are presented in Table 1 below.

[5] UNDP. 2015. *Guidance on the conduct and reporting of the Economic and Financial Analysis of Climate Change Adaptation and Mitigation Projects and Programmes*. UNDP.
[6] It is generally pointed out that the presence of a large informal sector explains this low level of official unemployment. Furthermore, with approximately 40% of Thailand's population engaged in agriculture, there is a high degree of underemployment and off-season unemployment in Thailand. These could equally justify the use of a shadow wage rate lower than the financial cost of labor.

Table 1: Outputs and Activities

Outputs		Activities
1.	Enhance climate and risk informed planning in the water and agricultural sectors through improved climate information and cross sectoral coordination	Activity 1.1: Strengthening capacity to generate tailored climate information to inform water management and agriculture planning Activity 1.2: Facilitating inter-ministerial coordination for climate-informed and integrated planning Activity 1.3: Expanding access to climate information for application at the household level
2.	Improve water management through strengthened infrastructure complemented by EbA measures, for greater resilience to climate change impacts	Activity 2.1: Climate-informed engineering designs for the 13 schemes of the Yom-Nan river basin and upgrade of 2 water infrastructure Activity 2.2: Complementing of grey infrastructure with EbA measures and integration of EbA approaches into water management policy and planning
3.	Reduce volatility of agriculture livelihoods in drought and flood prone areas through strengthened extension support and local planning, investment in on-farm adaptation measures and greater access to finance and markets	Activity 3.1: Application of climate information in household agriculture planning and strengthening of related support through extension services Activity 3.2: Implementation of on-farm climate resilient measures to improve drought and flood resilience and improved access to finance for sustainable agriculture Activity 3.3: Capacity building for farmers to support market access for climate resilient agriculture products
4.	Project management	

12. The proposal presents the breakdown of the total cost of the project and of its funding across the above 4 project outputs as shown in Table 2. Output 2 represents the bulk (approximately 74%) of the proposed investment project.

Table 2
Project Cost, GCF Funding, and Co-financing across Outputs[7]

Output	Total cost ($)	GCF funding	Co-financing
Output 1	3,214,627	1,683,112	1,531,515
Output 2	23,125,259	9,640,410	13,484,849
Output 3	5,978,332	5,616,873	361,459
Management	1,593,105	593,105	1,000,000
Total	**33,911,323**	**17,533,500**	**16,377,823**

13. The budget proposal presents an annual breakdown of both the GCF grant and the co-financing over the 5 years of project implementation for each output of the project. These are presented in Table 3 and 4 respectively.

Table 3: Annual Breakdown of the GCF Financing of the Capital Cost

Output	Total	2021	2022	2023	2024	2025
Output 1	1,683,112	326,362	577,282	596,932	85,943	96,593
Output 2	9,640,410	1,663,542	3,182,442	2,692,762	1,423,922	677,742

[7] Please note that all numbers have been rounded up to closest decimals.

Output 3	5,616,873	319,103	1,322,253	2,228,982	1,080,582	665,953
Management	593,105	132,833	110,721	110,720	116,362	122,469
Total	**17,533,500**	**2,441,840**	**5,192,698**	**5,629,396**	**2,706,809**	**1,562,757**

Table 4: Annual Breakdown of the Co-Financing of the Capital Cost

Output	Total	2021	2022	2023	2024	2025
Output 1	1,531,515	303,030	303,030	308,485	308,485	308,485
Output 2	13,484,849	2,121,212	2,121,212	3,787,879	4,696,970	757,576
Output 3	361,459	52,634	75,114	71,320	87,638	74,753
Management	1,000,000	272,727	272,728	212,121	121,212	121,212
Total	**16,377,823**	**2,749,603**	**2,772,084**	**4,379,805**	**5,214,305**	**1,262,026**

14. Summing the GCF grant (from Table 3) and the co-financing (from Table 4) portions provides a complete breakdown of the total estimated project cost across outputs and years (Table 5).

Table 5
Estimated Project Total Cost Across Years and Outputs

Output	Total	2021	2022	2023	2024	2025
Output 1	3,214,627	629,392	880,312	905,417	394,428	405,078
Output 2	23,125,259	3,784,754	5,303,654	6,480,641	6,120,892	1,435,318
Output 3	5,978,332	371,737	1,397,367	2,300,302	1,168,220	740,706
Management	1,593,105	405,560	383,449	322,841	237,574	243,681
Total	**33,911,323**	**5,191,443**	**7,964,782**	**10,009,201**	**7,921,114**	**2,824,783**

15. Output 1, 3 and 4 are not amenable to the conduct of a cost-benefit analysis on their own. These three outputs are best understood as contributing to achieving the outcomes and targets identified in Output 2. While the benefits of those Outputs are not amenable to a separate assessment of their respective benefits, their costs need to be accounted for in the economic analysis. The costs of those Outputs in any given year of project implementation are applied to Output 2. This leads to the cost distribution presented in Table 6.

Table 6
Estimated GCF Grant and Government Co-Financing

Output	Total	2021	2022	2023	2024	2025
Output 2	33,911,323	5,191,443	7,964,782	10,009,201	7,921,114	2,824,783
Total	**33,911,323**	**5,191,443**	**7,964,782**	**10,009,201**	**7,921,114**	**2,824,783**

16. The above distribution of capital cost across Year 1 to 5 is used in the economic analysis. The above calculations leading to Table 6 appear in the worksheet "Project cost" of the attached Excel Spreadsheet.

III.2 Operation and maintenance costs

17. Once the totality of assets is in place, annual operation and maintenance (O&M) costs have been estimated to be $1,257,504. However, these full O&M costs are incurred only upon complete implementation of the activities of the output. Hence, not all of the above operation and maintenance costs (and not all of the project benefits) will be incurred in Year 1, 2, 3, 4, or 5 of project implementation. Complete O&M costs will start applying the year following completion of project

implementation. For purpose of the economic analysis, it is assumed that O&M costs arise in direct proportion of the capital cost disbursed.

18. For purpose of illustration, note in Table 7 that 15.3% of the total cost of the project will be disbursed in Year 1 and 38.8% will have been disbursed by the end of the second year. It is thus assumed that 15.3% of the total O&M costs of $1,257,504 will be in 2022 (one year after implementation) and 38.8% of the O&M will apply in 2022. The resulting schedule of O&M is presented in Table 8 below. The calculations are shown in the worksheet “Project cost”, row 44 to 58.

Table 7
Annual and Cumulative Percentages of Capital Disbursement (%)

	2021	2022	2023	2024	2025
Annual	15.3	23.5	29.5	23.4	8.3
Cumulative	15.3	38.8	68.3	91.7	100.0

Table 8
Schedule of Operation and Maintenance Costs ($)

	2021	2022	2023	2024	2025	2026+
Output 2	-	192,510	487,861	859,023	1,152,755	1,257,504

IV. Net Economic Benefits of Project’s Outputs

IV.1 Nature of benefits

19. The project realizes two important benefits of a different nature. First, climate change (projected changes in temperature and precipitation) are expected to have an adverse impact on agricultural productivity in the project area. Secondly, extreme weather events (extreme precipitation with associated floods, as well as drought) are expected to occur at a greater frequency and greater intensity in forthcoming decades. The proposed investment project is expected to alleviate both of these impacts. Each are discussed in turn below.

IV.2 Climate change impacts: Impacts on agricultural productivity

20. In order to estimate the potential benefits of the project on agriculture, the following 5 issues must be addressed:

Issue 1: Determine the number of rais (area) benefiting from the project investment.

Issue 2: Assess the potential impacts of climate change on productivity without project (scenario with climate change, without project).

Issue 3: Assess the potential impacts of the project on productivity (scenario with climate change, with project).

The difference between the “yield with project” and “yield without project” will be the benefits of the project measured in physical terms (incremental quantity of agricultural output).

Issue 4: Compute the net economic returns of the incremental agricultural output allowed by the project.

Each of these issues are addressed below.

Issue 1: How many rais will benefit from project?

21. The Technical Feasibility report determines that a total of 312,600 rais will benefit from the project, as detailed in Table 9 below. The majority of the cultivated area to benefit from the project is located in the province of Phitsanulok.

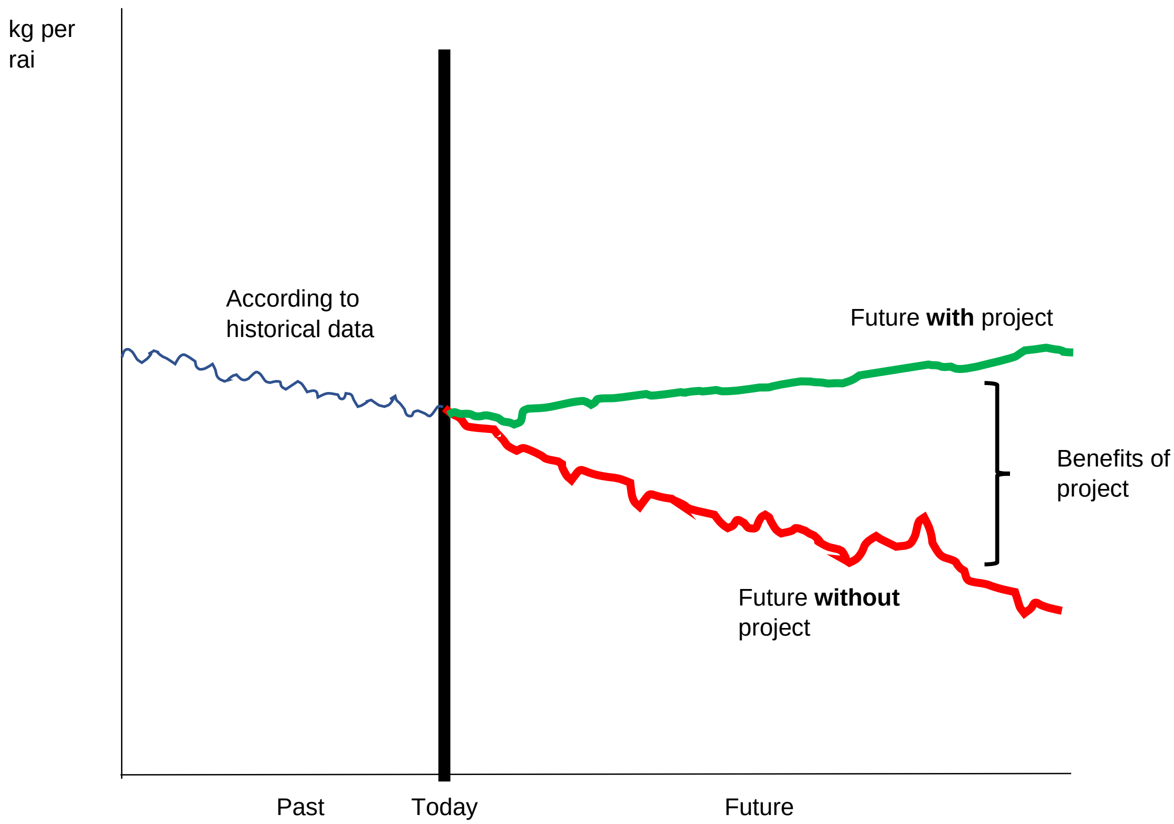
Table 9: Quantity of Rais Beneficiary of the Project

Province	District	Sub-district	Cultivated area (rai)
Uttaradit	Phichai	Phrayaman	21,264
		Thamafuang	20,104
		Korrum	10,861
Total			52,229
Phitsanulok	PhromPhiram	Wang Won	38,338
		Taluk Thiam	19,697
		Si Phirom	24,508
		NongKhaem	13,319
		Matong	1,895
		Tha Chang	7,583
	Muang	Ban Krang	9,784
	Bang Rakam	Tha Nang Ngam	28,668
		Churn SaengSongkram	21,593
		Bang Rakam	1,555
Total			166,940
Sukhothai	Kong Krilat	Ban Mai Suk Kasem	19,883
		KokRaet	20,626
		KriNok	27,264
		KriKlang	11,306
		KriNai	4,951
		Dong Dueai	672
	Srinakorn	Klongmaplup	355
		Nongbuo	1,633
	Sawankhalok	Paknam	6,742
Total			93,431
Total			**312,600**

Issue 2: Future yield with climate change, without project.

22. As shown in Figure 1, the quantified benefits of the project is estimated by comparing productivity in the future with climate change under two different scenarios: One scenario without project, and one scenario with project.

Figure 1: Quantifying the Expected Benefits of the Project on Agriculture



23. In order to estimate the potential economic benefits of the project, we need to determine what could be the yield in the future (on those rais benefiting for the project) with climate change, but without the proposed investment project. For this purpose, recent historical data pertaining to existing yield is informative.

24. Section 2.1.5 of the Feasibility Report presents the following data for each province of the project. In Uttaradit, average yield over the period 2013-2018 reached approximately 616 kilograms (kg) per rai. In Phitsanulok and Sukhothai, average yield over the same period is estimated to be 586 and 566 kg per rai respectively (Table 10) – as shown in worksheet “Projected yield”, row 1 to 20 of the Excel file.

Table 10: Recent Yields

		2013	2014	2015	2016	2017	2018
Phitsanulok							
	Planted area (rai)	1,444,567	1,359,936	1,036,758	1,304,183	1,227,901	1,339,068
	Harvested area (rai)	1,414,567	1,344,194	1,287,755	1,254,339	1,227,901	1,298,896
	Production (tons)	876,308	782,776	725,113	747,444	723,701	736,701
	Yield (kg per rai)	619	582	563	596	589	567
	Average yield (2013-2018)	**586**					
Sukhothai							
	Planted area (rai)	1,126,723	1,036,858	1,102,633	960,884	1,034,748	1,036,081
	Harvested area (rai)	1,102,800	1,012,633	729,874	952,449	896,574	1,000,081
	Production (tons)	645,638	577,418	392,207	534,346	499,245	583,007
	Yield (kg per rai)	585	570	537	561	557	583
	Average yield (2013-2018)	**566**					
Uttaradit							
	Planted area (rai)	616,339	589,182	473,513	544,985	568,725	569,625
	Harvested area (rai)	610,573	585,648	459,307	536,950	556,242	565,314
	Production (tons)	388,020	361,239	292,809	322,086	334,022	340,867
	Yield (kg per rai)	636	617	638	600	600	603
	Average yield (2013-2018)	**616**					

25. Projecting the possible impacts of climate change on agricultural productivity in the project area remains a difficult exercise. However, in Thailand, several studies have investigated the effect of climate change on agriculture. Results from these studies vary significantly as results depend on the nature of the assumed baseline, emissions scenarios, climate simulation models, and the economic modelization approach.

26. By using the Crop Environment Resource Synthesis (CERES) model, the Office of Environmental Policy and Planning (2000)[8] has estimated that rice grown under rainfed conditions was found to be highly vulnerable to climate change. The study estimated that yields of rice could decline by as much as 57% compared to the baseline.

27. In a more recent paper, Felkner et al (2009)[9] used the computer crop growth model DSSAT to estimate the impacts of climate change under the A1FI (highest emissions trajectory scenario) and the B1 (lowest emissions trajectory scenario) for the period 2040-2069. The authors estimate a reduction in aggregate yield ranging between 3.5% and 13.8% compared to neutral climate simulations.

28. Using a Ricardian approach, Attavanich (2012) estimates the impacts of climate change on farm value under the A2 and B2 scenarios for the 2040-2049. Results indicate that farmland values per rai are projected to decrease from $2,703 per rai to $2,068 and $2,538 per rai in climate scenarios A2 and B2, respectively. This would indicate decreases in agricultural output ranging approximately between 6.1% and 23.5%.

29. The Asian Development Bank in its 2009 report entitled *The Economics of Climate Change in South East Asia: A Regional Approach*, estimated a potential reduction of rice yield under the B2 and A1FI emissions scenarios of approximately 5% and 15% respectively by 2050.

30. Given the above range of the estimated impacts of climate change on rice productivity, the economic analysis assumes a reduction of 5%, 10%, and 15% and 20% by 2044 (the end of the period of the

[8] Office of Environmental Policy and Planning. 2000. Thailand's Initial National Communication under the United Nations Framework Convention on Climate Change. Ministry of Science. Technology. and Environment. Bangkok, Thailand. 100 p.
[9] Felkner, J. et al. 2009. Impact of climate change on rice production in Thailand. *American Economic Review*. 99. 2. 205-210.

economic analysis). A linear extrapolation is applied to assess annual yield reductions from existing levels to the estimated reduced yield of 2044. Results for various time slices are presented in Table 11 below. Annual results are presented in the worksheet "Projected Yield", Row 22 to 41.

Table 11: Projected Yield with Climate Change without Project for Selected Years (kg per rai)

	2021	2025	2030	2035	2040	2045
Minus 5% by 2042						
Phitsanulok	582.6	578.1	572.5	566.8	561.2	555.6
Sukhothai	562.1	557.6	552.0	546.3	540.7	534.0
Uttaradit	612.3	607.8	602.1	596.5	590.9	581.7
Minus 10% by 2042						
Phitsanulok	579.2	570.2	559.0	547.7	536.4	525.4
Sukhothai	558.7	549.7	538.5	527.2	515.9	506.9
Uttaradit	608.9	599.9	588.6	577.4	566.1	552.1
Minus 15% by 2042						
Phitsanulok	575.9	562.3	545.4	528.5	511.6	495.2
Sukhothai	555.4	541.8	524.9	508.0	491.1	477.8
Uttaradit	605.5	592.0	575.1	558.2	541.3	520.4
Minus 20% by 2042						
Phitsanulok	572.5	554.4	531.9	509.4	486.8	465.2
Sukhothai	552.0	533.9	511.4	488.9	466.3	448.8
Uttaradit	602.1	584.1	561.6	539.0	516.5	488.9

31. Given the number of rais included in the project for each province (Table 9), estimates of aggregate production (with climate change without project) are presented in Table 12 below for different scenarios pertaining to the impacts of climate change on agricultural yield. Please note that aggregate yields presented in Table 12 are in tons. Annual values are presented in row 49 to 70 of the worksheet "Projected yield".

Table 12: Projected Yield with Climate Change without Project (tons)

	2021	2025	2030	2035	2040	2045
Minus 5% by 2042						
Phitsanulok	112,212	111,344	110,259	109,174	108,089	107,014
Sukhothai	56,212	55,761	55,198	54,634	54,071	53,401
Uttaradit	12,246	12,156	12,043	11,930	11,817	11,633
Total	**180,670**	**179,261**	**177,500**	**175,738**	**173,977**	**172,049**
Minus 10% by 2042						
Phitsanulok	111,561	109,825	107,655	105,484	103,314	101,187
Sukhothai	55,874	54,972	53,845	52,718	51,592	50,692
Uttaradit	12,178	11,998	11,772	11,547	11,322	11,041
Total	**179,613**	**176,795**	**173,272**	**169,750**	**166,227**	**162,920**
Minus 15% by 2042						
Phitsanulok	110,910	108,306	105,050	101,794	98,539	95,381
Sukhothai	55,536	54,183	52,493	50,803	49,112	47,780
Uttaradit	12,110	11,840	11,502	11,164	10,826	10,409
Total	**178,556**	**174,329**	**169,045**	**163,71**	**158,477**	**153,570**
Minus 20% by 2042						
Phitsanulok	110,259	106,786	102,445	98,105	93,764	89,596
Sukhothai	55,198	53,395	51,141	48,887	46,633	44,879
Uttaradit	12,043	11,682	11,231	10,781	10,330	9,779
Total	**177,500**	**171,863**	**174,818**	**157,772**	**150,727**	**144,254**

Issue 3: Future yield with climate change with project.

32. Activities of a similar nature have been recently implemented in Thailand. Under such circumstances, yields have been shown to reach between 750 and 1,000 kg per rai. For purpose of this economic analysis, the lower bound value of 750 kg per rai is used in the analysis.

33. In order to compute agricultural productivity changes *with the project* over time, different scenarios are possible. These include:

Scenario 1: The yield per rai remains constant (at the levels presented in paragraph 31) until all project activities are completed in 2024 and then increase at once (on all 312,600 rais) to 750 kg per rai.

Scenario 2: The yield per rai gradually increases (on all 312,600 rais) from the estimates presented in paragraph 31 in 2020 to 750 kg per rai in 2023 once all project activities are completed.

Scenario 3: The yield per rai increases from estimates presented in paragraph 31 in 2020 to 750 kg per rai only on those rais benefiting from project interventions in any given year of project implementation, where the annual proportion of rais benefiting from project interventions is provided by cumulated percentages of capital disbursement presented in Table 6.

34. For purpose of the economic analysis, Scenario 3 is considered appropriate. Hence, as 16.5% of the capital investment is disbursed in 2021, it is assumed that 15.3% of the rais included in the project will yield 750 kg per rai as of 2022. Similarly, as 38.8% of the capital disbursement will have been disbursed by 2021, it is assumed that 38.8% of the rais will yield 750 kg per rai as of 2022. A similar rationale applies to remaining years of project implementation. This assumption is consistent with the treatment of operation and maintenance costs presented in Section III.2 above. It is assumed that those rais not yet having benefited from project interventions deliver the productivity yield with climate change (but without project yet) as presented in Table 8 (albeit, all rais will have benefited from project interventions by the beginning of 2025). The computation of total aggregate production is presented in the worksheet “Projected yield”, row 72 to 98.

35. The difference between the expected yields with project and the estimated yields without project presented provides the estimated benefits of the project – measured in incremental quantity of rice (in tons) provided by the project. These are presented in row 100 to 122 of the worksheet “Projected yield”, and summarized in Table 13 below.

Table 13: Estimated Benefits (Incremental quantity) of the Project (tons)

	2021	2025	2030	2035	2040	2045
Minus 5% by 2042						
Phitsanulok	-	30,348	34,191	35,276	36,361	37,436
Sukhothai	-	17,636	19,802	20,366	20,929	21,599
Uttaradit	-	2,607	2,957	3,070	3,183	3,367
Total	**-**	**50,592**	**56,950**	**58,712**	**60,473**	**62,401**
Minus 10% by 2042						
Phitsanulok	-	31,741	36,795	38,966	41,136	43,263
Sukhothai	-	18,359	21,155	22,281	23,408	24,308
Uttaradit	-	2,752	3,228	3,453	3,678	3,959
Total	**-**	**52,852**	**61,177**	**64,700**	**68,223**	**71,530**
Minus 15% by 2042						
Phitsanulok	-	33,134	39,400	42,656	45,911	49,069
Sukhothai	-	19,083	22,507	24,197	25,888	27,220
Uttaradit	-	2,897	3,498	3,836	4,174	4,591
Total	-	**55,113**	**65,405**	**70,689**	**75,973**	**80,880**
Minus 20% by 2042						
Phitsanulok	-	34,526	42,004	46,345	50,686	54,854
Sukhothai	-	19,806	23,859	26,113	28,367	30,121
Uttaradit	-	3,041	3,769	4,219	4,670	5,221
Total	-	**57,373**	**69,632**	**76,678**	**83,723**	**90,196**

Issue 4: Net economic returns of agricultural output.

36. The total household income earned after agricultural expenses (and related costs) are deducted, was on average 73,967 THB (US$2,138) a year on average.

37. The net return amounts to approximately 2,550 THB per rai. Assuming an average yield of approximately 550 kg per rai, this would represent an average net return of approximately 5 THB per kilo. The above estimates would present a net economic return reaching approximately $0.15 per kilo. This number is used as a baseline to estimate the aggregate benefits of the incremental agricultural output allowed by the project.

38. Aggregate net economic returns of the incremental agricultural output are presented in Table 14 under different climate change scenarios.

Table 14: Estimated Benefits of the Project on Agricultural Output ($)

	2021	2025	2030	2035	2040	2045
Minus 5% by 2042						
Phitsanulok	-	4,552,206	5,128,623	5,291,407	5,454,191	5,615,366
Sukhothai	-	2,645,440	2,970,335	3,054,855	3,139,374	3,239,801
Uttaradit	-	391,125	443,568	460,472	477,375	504,985
Total	**-**	**7,588,771**	**8,542,527**	**8,806,734**	**9,070,941**	**9,360,152**
Minus 10% by 2042						
Phitsanulok	-	4,761,120	5,519,304	5,844,873	6,170,441	6,489,516
Sukhothai	-	2,753,910	3,173,181	3,342,220	3,511,258	3,646,177
Uttaradit	-	412,819	484,137	517,945	551,752	593,785
Total	**-**	**7,927,849**	**9,176,623**	**9,705,037**	**10,233,451**	**10,729,479**
Minus 15% by 2042						
Phitsanulok	-	4,970,034	5,909,986	6,398,338	6,886,690	7,360,411
Sukhothai	-	2,862,381	3,376,027	3,629,585	3,883,143	4,082,980
Uttaradit	-	434,513	524,706	575,418	626,129	688,671
Total	**-**	**8,266,928**	**9,810,719**	**10,603,340**	**11,395,961**	**12,132,062**
Minus 20% by 2042						
Phitsanulok	-	5,178,948	6,300,667	6,951,803	7,602,939	8,228,050
Sukhothai	-	2,970,851	3,578,873	3,916,950	4,255,027	4,518,092
Uttaradit	-	456,207	565,275	632,891	700,506	783,218
Total	**-**	**8,606,006**	**10,444,815**	**11,501,643**	**12,558,472**	**13,529,361**

IV.3 Climate change impacts: Extreme weather events

39. As indicated in the Feasibility Report, the Yom-Nan Project Improvement is a part of flood alleviation plan of the Royal Irrigation Department to reduce flood damage along the Yom River from Sawan Khalok to Bang Rakam districts and protect Mueang Sukhothai from flooding. Without improvement of Khlong Nam Lai and the Old Yom River, the diverted flood water from the Yom River at Hok Bat Regulator at Si Satchanalai district cannot be increased from 250 to 350 cms. Therefore, the improvement can reduce flood peak along the Yom River from Sawan Khalok to Bang Rakam districts at a maximum discharge of 100 centimeters.

40. According to the direct flood damage inventory at district level by the Department of Disaster Prevention and Mitigation (DDPM) and the recorded maximum water level at gauging stations along the Yom River from Sawan Khalok to Bang Rakam districts, the relationship between the damage costs and the maximum water levels can be determined. Table 15 shows the estimated flood damage cost reduction at each return period in cases of without and with project. The flood damage reduction cost is considered as the flood benefit of this project improvement. Given the estimates presented in Table 14, *expected* annual benefits amount to approximately 60 million baht, or approximately USD 2 million.

Table 15: Estimated Reduction in Flood Damages (Thai Baht)

Return period	Estimated damages without project	Estimated damages with project	Reduction in damages
1-in-5	18,970,000	0	18,970,000
1-in-10	330,210,000	98,380,000	231,830,000
1-in-25	1,222,500,000	735,450,000	487,050,000
1-in-50	1,737,070,000	1,076,960,000	660,110,000

41. It is of importance to note that the estimated benefit (mitigation of expected damages) of approximately USD2 million is realized only upon completion of all project activities in 2025. For purpose of consistency with previous components of the economic analysis, it is assumed that the benefits are

effectively realised in proportion of cumulated capital disbursement in any given year. The outcome is shown in Table 16. Computations are shown in the worksheet “Flood damages”.

Table 16: Schedule of Expected Benefits from Flood Mitigation ($)

2021	2022	2023	2024	2025	2026+
-	304,449	771,538	1,358,521	1,823,049	1,988,707

V. Net Present Value and Internal Rate of Return

42. Given the above assumptions, the net present value (NPV) and internal rate of return (IRR) of the proposed investment project are presented in Table 17 below. The table shows the NPV to be positive under the assumed range of impacts of climate change on agricultural productivity, and an IRR in excess of 20%.

Table 17: Estimated Net Present Value and Internal Rate of Return

Scenario[1]	Net present value ($)	Internal rate of return (%)
Minus 5% by 2042	36,765,294	26.8
Minus 10% by 2042	41,269,784	28.2
Minus 15% by 2042	45,781,255	29.5
Minus 20% by 2042	50,292,239	30.8

[1] For purpose of clarity, the scenarios presented are the assumed impacts of climate change by 2045 on agricultural productivity in the absence of the project.

VI. Sensitivity analysis

43. We first assume an increase of 20% in the total cost of the project. As shown in the table below, the NVP and IRR remain significantly favorable.

Table 18: Estimated Net Present Value and Internal Rate of Return
Cost Increase: +20%

Scenario[1]	Net present value ($)	Internal rate of return (%)
Minus 5% by 2042	29,872,929	21.6
Minus 10% by 2042	34,377,929	22.9
Minus 15% by 2042	38,888,890	24.1
Minus 20% by 2042	43,399,873	25.3

44. We then assume a decrease in total benefits of 20%. As shown in the table below, the NVP and IRR remain significantly favorable.

Table 19: Estimated Net Present Value and Internal Rate of Return
Benefit Decrease: -20%

Scenario[1]	Net present value ($)	Internal rate of return (%)
Minus 5% by 2042	22,519,870	20.6
Minus 10% by 2042	26,123,461	21.8
Minus 15% by 2042	29,732,639	23.0
Minus 20% by 2042	33,341,426	24.2

45. Finally, we have assumed a simultaneous increase in cost of 20% and decrease in benefits of 20%. As shown in the table below, the economic efficiency of the project remains significant.

Table 20: Estimated Net Present Value and Internal Rate of Return

Scenario[1]	Net present value ($)	Internal rate of return (%)
Minus 5% by 2042	15,627,504	16.3
Minus 10% by 2042	19,231,096	17.5
Minus 15% by 2042	22,840,273	18.6
Minus 20% by 2042	26,449,060	19.7