Annex 3b

Financial and Economic Analysis

GCF Funding Proposal

Thai Rice:
Strengthening Climate-Smart Rice Farming

July 2023

Version 3

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Annex 3b: Financial and Economic Analysis

This Annex should be read in conjunction with the economic and financial model in Annex 3a.

I. Financial Analysis

The vast majority of the GCF grant (EUR 30.6 million out of EUR 38.2 million) is dedicated to technical assistance and other public good-type activities, for which the use of a grant is fully justified. Only EUR 7.6 million of the budget is used for financial incentives to rice farmers that generate financial reflows. These incentives are directed to eligible farmers that adopt a recommended package of climate-smart agriculture (CSA) measures, as described in the FP and FS documentation and are set at THB 7,000 for farmers whose CSA package includes expensive LLL services and THB 4,000 for farmers whose CSA package does not includes LLL. These incentives, which may be revised upon project inception to factor in input and equipment prices at the time, are justified based on a detailed financial model and additional considerations as discussed below. Please refer to the three ‘FIRR’ sheets in the Excel model.

Baseline Assumptions

We have modelled the incremental cashflows for farmers that switch from conventional rice farming to CSA over a 5-year CSA implementation cycle.

We started from simulating the cashflows of a representative baseline rice farm in each of the three target regions: Central Plains, North-East and North. The representative farm aims to capture the conditions of the majority of – but not all – farms in each region. Exceptions exist. Assumptions – derived from literature, the findings of an extensive market study commissioned for the project (by CIAT), as well as IRRI data and GIZ field survey data collected from the NAMA Support Project (NSP) and other projects (see ‘Sources’ column) – are summarised in Table 1 below. All assumptions have been thoroughly analyzed by GIZ experts based on their experience and prior track record in CSA.

The model assumes that the farms in each region apply CSA to 72% of the farmland (weighted average of 80% for megafarms and 60% for non-megafarms). This is realistic from an agronomic perspective and is affirmed by the empirical experiences of the foundation and baseline projects: farmers tend to have separate smaller plots and only apply the CSA practices to their ‘main plot’, and plots differ in their biophysical suitability for certain technologies (irrigation access, soil-type, slopes, etc.). Mega-farmers generally have more consolidated and established plots, as well as better access to support services: hence the higher share of megafarm land converted to CSA.

Table 1: Baseline Farm Assumptions

Assumptions	Central Plains	North-East	North
Avg. farm size (rai)	22	16	11
% area where CSA implemented	72%	72%	72%
Avg. farm area switched to CSA (rai)	15.8	11.5	7.9
Avg. farm area switched to CSA (ha)	2.5	1.8	1.3
Ownership or rental	50% owned and 50% rented	100% owned	50% owned and 50% rented
Growing seasons	Wet and dry seasons	Wet season only (irrigation not available)	Wet and dry seasons
Rice yield (t/rai/season)	0.8	0.4	0.95
Rice yield (t/ha/season)	5.0	2.5	5.9
Climate change impact on yield	2% decline in Year 4, 4% decline in Year 5	2% decline in Year 4, 4% decline in Year 5	2% decline in Year 4, 4% decline in Year 5
Rice price for main rice variety produced (THB/t)	8,000	13,500	9,000
Baseline revenues (Year 1, THB)	202,752	62,208	135,432
Operating costs as % of revenues:[1]			
Land rental	11.3%	N.A.	8.8%
Land preparation	7.8%	12.5%	11.7%
Planting	8.8%	12.0%	19.7%
Irrigation	9.1%	N.A.	4.7%
Fertilization	19.7%	32.6%	22.3%
Pesticides	11.6%	10.3%	8.0%
Harvesting	9.1%	13.0%	8.4%
Miscellaneous	3.9%	4.0%	4.2%
Total	81.2%	84.4%	87.8%
Pre-tax profit (THB/year)	38,095	9,711	16,497
Pre-tax profit (EUR/year)	1,030	263	446
Pre-tax profit per rai (EUR/year)	65	23	56

The situation of the representative baseline farms can be summarised as follows:

- Central Plains: the largest farms with relatively high yields, produced both in the wet and dry seasons. The rice produced is of average quality and commands the lowest prices of all three regions. Fertilizers, pesticides, land rental and irrigation are the largest cost items, as a percentage of revenues. Because of the large farm size, double growing season and relatively high yields, the representative farm in the Central Plains produces the highest pre-tax profits, both in absolute terms (EUR 1,030/year) and per unit area (rai) (EUR 65).

[1] See Excel model for detailed assumptions.

- North-East: mid-size farms, not irrigated and therefore producing only in the wet season, with very low yields due to not very fertile soils. The rice produced, however, is of premium quality and attracts a high price. A high-cost base, despite farmers not paying rent (land is mostly owned) and mostly being without irrigation. Premium rice prices are not sufficient to offset low yields, smaller farm size and high costs. The representative farm in the North-East produces the lowest pre-tax profits, both in absolute terms (EUR 263/year) and per rai (EUR 23).

- North: the smallest farms producing the highest yields (partly due to application of transplanting), over two seasons. Rice is of better quality than in the Central Plains but is not at a premium level. Operating costs in these small, hillside farms are the highest as a percentage of revenues. Fertilizers, planting and land preparation are the largest cost items. The representative farm in the North produces low pre-tax profits in absolute terms (EUR 446/year) due to small farm size but relatively high pre-tax profits per rai (EUR 56) due to high yields.

In general, rice farming in all three regions produces only subsistence income (if at all) for the farmers and their families. Most farmers complement farm income with second jobs, typically as paid labour, as well as social security subsidies provided by the government. The financial model, however, only looks at farm income and the effects on it of switching from conventional farming to CSA.

CSA Assumptions

Farmers will have the opportunity to choose from a variety of CSA technologies based on the specific conditions of their farms. Modelling all possible permutations would not be practical. The approach chosen in the financial model is to model a representative CSA package, combining a few technologies in each region. Table 2 summarizes the technology mix and assumptions.

Table 2: CSA Assumptions

	Central Plains	North-East	North
LLL	• Service fee: EUR 375/ha • Frequency: once every 5 years • Increased yield vs. baseline: 5% • Reduced water pumping cost: THB 35.5/rai/year • Reduced fertilizer cost: THB 35.5/rai/year • Reduced seed cost: THB 35.5/rai/year	• Service fee: EUR 375/ha • Frequency: once every 5 years • Increased yield vs. baseline: 7% (starting from low baseline yield) • Reduced water pumping cost: N/A, as farm does not irrigate • Reduced fertilizer cost: THB 17.8/rai/year • Reduced seed cost: THB 17.8/rai/year	• Not applicable in typical farm due to hilly terrain
AWD	• Modest yield decrease: -2% vs. baseline	• Not applicable in typical farm due to lack of access to reliable	• Modest yield decrease: -2% vs. baseline in year 1 to -1% by year 3

	• Reduced irrigation cost: -20% vs. baseline	irrigation system. Limited scope of applicability in certain locations with good access to the irrigation system.	• Reduced irrigation cost: -20% vs. baseline
SSNM	• No significant yield increase vs. baseline; approach focuses on maintaining yield while reducing chemical fertilizer input • Fertilizer cost decrease: THB 200/rai/season • Shared fertilizer mixing machine: THB 7,500 every 5 years • Bio-pesticide cost increase: THB 160/rai/season	• Yield increase vs. baseline: 3% due to increased application of organic material • Fertilizer cost decrease: THB 200/rai/season • Bio-pesticide cost increase: THB 160/rai/season • Sprayer cost increase: THB 50/rai/season	• Yield increase vs. baseline: 1.5% gradually by year 3 due to increased application of organic material • Fertilizer cost decrease: THB 200/rai/season • Bio-pesticide cost increase: THB 160/rai/season • Sprayer cost increase: THB 50/rai/season
SSM	• Not applicable in typical set of interventions as the baseline already indicates a low burning rate of rice straw	• Number of straw bales produced: 30/rai • Selling price: THB 25/bale • Bale collection service: THB 10/bale	• Number of straw bales produced: 30/rai • Selling price: THB 19/bale • Bale collection service: THB 15/bale
Across technologies	• Extra labour for CSA implementation: THB 55/rai/season	• Extra labour for CSA implementation: THB 55/rai/season	• Extra labour for CSA implementation: THB 55/rai/season

CSA Financial IRR Without GCF Grant

Based on the assumptions above, we calculated the incremental cashflows generated annually over a 5-year period for farms that switch from conventional farming to CSA and derived a financial IRR (FIRR) and NPV. The results are summarized in Figure 1.

Figure 1: CSA Financial IRR and NPV Without GCF Grants (5-year period)

Central Plains					
Additional CSA cashflows (THB/year)					
From LLL	(23,339.3)	11,825.5	11,825.5	11,622.8	11,225.4
From AWD	(348.5)	(348.5)	(348.5)	(267.4)	(108.4)
From SSNM	(6,232.8)	1,267.2	1,267.2	1,267.2	1,267.2
From extra CSA-related labor	(1,742.4)	(1,742.4)	(1,742.4)	(1,742.4)	(1,742.4)
Total cashflow increase (decrease)	(31,663.0)	11,001.8	11,001.8	10,880.2	10,641.7
CSA IRR without grant (%)	**14.2%**				
CSA NPV without grant (THB)	**2,612.7**				

Northeast					
Additional CSA cashflows (THB/year)					
From LLL	(20,810.6)	4,763.8	4,763.8	4,676.7	4,506.0
From AWD	-	-	-	-	-
From SSNM	1,751.0	1,751.0	1,751.0	1,713.7	1,640.6
From SSM	450.0	450.0	450.0	450.0	450.0
From extra CSA-related labor	(633.6)	(633.6)	(633.6)	(633.6)	(633.6)
Total cashflow increase (decrease)	(19,243.2)	6,331.2	6,331.2	6,206.8	5,962.9
CSA IRR without grant (%)	**11.2%**				
CSA NPV without grant (THB)	**437.1**				

North					
Additional CSA cashflows (THB/year)					
From LLL	-	-	-	-	-
From AWD	(1,425.6)	(748.4)	(71.3)	(44.2)	8.9
From SSNM	(158.4)	1,195.9	1,873.1	1,832.5	1,752.8
From SSM	240.0	240.0	240.0	240.0	240.0
From extra CSA-related labor	(871.2)	(871.2)	(871.2)	(871.2)	(871.2)
Total cashflow increase (decrease)	(2,215.2)	(183.7)	1,170.6	1,157.1	1,130.5
CSA IRR without grant (%)	**13.6%**				
CSA NPV without grant (THB)	**206.1**				

The conversion to CSA produces a positive financial IRR and NPV in each representative farm:

- For the Central Plains representative farm, the FIRR of switching to CSA is 14.2%. A substantial decrease in farm cashflows in Year 1, when LLL is applied at a considerable cost (in addition to smaller negative cashflow impacts from other technologies), is more than offset by the increase in cashflows over the subsequent 4 years.

- A similar dynamic takes place in the representative Northeast farm. Here, however, the yield increase from LLL and SSNM applies only to one farming season and generates proportionally lower positive cashflows than in the Central Plains. The FIRR is therefore lower (11.2%).

- LLL is not applied in the representative farm in the North, due to the hilly and uneven terrain. Still, the conversion to CSA generates moderately negative cashflows in the first two years. The FIRR over 5 years is 13.6%.

Note that the above FIRRs and financial NPVs do not reflect the value of technical assistance farmers will receive to help them in the implementation of CSA. If farmers paid for that technical assistance (in the hypothetical scenario where there is an external provider willing to provide it for a fee), returns would be lower than those shown above.

It is also worth noting the high sensitivity of FIRRs to changes in yield (Table 3). Farmers are aware of the difficulty of predicting with certainty the change in yield derived from CSA and will therefore look cautiously at promises of large returns over 5 years.

Table 3: FIRR Sensitivity to Yields

	Central Plains		North-East		North	
	Yield	**FIRR**	**Yield**	**FIRR**	**Yield**	**FIRR**
Base case	LLL yield impact +5%	14.2%	LLL yield impact +7%	11.2%	SSNM yield impact +1.5% (gradually by Year 3)	13.6%
Downside	LLL yield impact +4%	2.2%	LLL yield impact +6%	5.0%	SSNM yield impact +1% (by Year 2)	-15.0%

Rationale for CSA Financial Incentives

While the financial IRR and NPV of a CSA conversion are attractive even before financial incentives (GCF grants), the latter are deemed essential for the quick uptake of CSA practices among the target farmers, for the following reasons:

- Farmers are inherently risk-adverse and skeptical of new technologies – in Thailand and elsewhere. The most powerful factor to persuade farmers to switch practices is evidence that the new practices have worked among peers. These behavioural features are well documented in the literature. For instance, a 2019 study by Attanavich et al.[2] finds that "almost 35% of Thai farmers have extreme degree of risk aversion and … higher degree of risk aversion especially among the low-tech farmers" and that "some 80% of Thai farmers express some degree of loss aversion … literature shows that loss aversion when combined with risk aversion could reduce farmers' incentive to invest and adopt new farming practices and/or technology". GIZ experience in Thailand during the NAMA Support Project and in agricultural projects in a range of other countries confirms this observation. The proposed GCF grant-funded financial incentives of THB 7,000 and THB 4,000 (with and without LLL, respectively) are intended to trigger early CSA conversion by a meaningful minority of rice farmers in the three regions. Specifically, the incentive programme would be in force for 2 years (likely starting in mid-2024) and would benefit a maximum of 14% of the ~253,400 farmers targeted for CSA conversion, approximately 36,000 farmers. These incentivised, early-adopters will be requested to share their evidence of CSA success with local peer farmers. It is expected that each early adopter will be able to generate these network effects with at least another 4 farmers, helping the project hit its target of ~253,400 CSA adopters over five years.

- Under the realistic assumptions described above, the switch to CSA would result in FIRRs and NPVs that, while positive, are not by themselves sufficient to persuade first-time adopters to switch. In addition, as noted above, FIRRs are highly sensitive to changes in yield. Farmers are aware of the difficulty of predicting the change in yield derived from CSA and will therefore look cautiously at promises of positive returns over 5 years. These doubts will subside in the future, once farmers – due to the GCF project – are no longer first-time adopters and have the required knowledge to implement CSA according to best practices.

[2] Attanavich et al. (2019). *Farms, Farmers and Farming: A Perspective through Data and Behavioral Insights.*

- The conversion to CSA negatively affects farm cashflows in the first year of adoption, especially when LLL is included. Figure 2 shows the change in annual farm cashflows post-CSA (without GCF grants). In the Central Plains, Year 1 cashflows would drop by 83%. The drop is even more pronounced in the North-East, where the baseline farm produces only a small cash surplus – here the adoption of CSA causes cashflows to drop into negative territory, requiring the farmer to either borrow or tap into his/her own savings to finance the adoption of CSA. Only in the North, where LLL is not applied, does the CSA conversion cause only a moderate reduction in cashflows in Years 1 and 2. The financial incentive is intended to partially buffer the drop in cashflows in Year 1 and therefore facilitate CSA conversion by early-adopters. With the objective of minimising concessionality, the THB 7,000 incentive in the Central Plains and North-East only partially covers the shortfall.

Figure 2: CSA Impact on Overall Farm Cashflows, Without GCF Grants (5-year period)

Central Plains					
Baseline cashflows (THB/year)	38,095.2	38,095.2	38,095.2	34,093.4	26,249.8
Additional CSA cashflows (THB/year)	(31,663.0)	11,001.8	11,001.8	10,880.2	10,641.7
Farm cashflows after CSA (THB/year)	6,432.2	49,097.0	49,097.0	44,973.6	36,891.6
Increase vs. baseline (%)	-83.1%	28.9%	28.9%	31.9%	40.5%
Northeast					
Baseline cashflows (THB/year)	9,711.4	9,711.4	9,711.4	8,491.4	6,100.3
Additional CSA cashflows (THB/year)	(19,243.2)	6,331.2	6,331.2	6,206.8	5,962.9
Farm cashflows after CSA (THB/year)	(9,531.8)	16,042.6	16,042.6	14,698.2	12,063.2
Increase vs. baseline (%)	-198.2%	65.2%	65.2%	73.1%	97.7%
North					
Baseline cashflows (THB/year)	16,496.6	16,496.6	16,496.6	13,827.4	8,595.9
Additional CSA cashflows (THB/year)	(2,215.2)	(183.7)	1,170.6	1,157.1	1,130.5
Farm cashflows after CSA (THB/year)	14,281.4	16,312.8	17,667.2	14,984.5	9,726.4
Increase vs. baseline (%)	-13.4%	-1.1%	7.1%	8.4%	13.2%

- While the financial incentives will result in an increase in FIRR and NPV, such increases are not deemed to be overly generous. Figure 3 shows the FIRR and NPV with GCF grant in the three regions. The FIRR in the Central Plains representative farm would increase to 27.5%. The FIRR in the North-East representative farm would increase to 36.2%.[3] NPVs would increase by amounts that reflect the size of the grant.
- With regards to proportionality of incentives to land size, when incentives are confirmed in year 1, flexibility will be introduced to upsize or downsize incentives proportionally to land size, for instance for farmers whose land size meaningfully deviates (e.g. at least +/-30%) from the average farm sizes presented in the financial model. This is meant to provide a fair treatment to farmers whose land sizes are outliers, while avoiding the administrative complexity of adjusting incentives for farmers whose land sizes are roughly in line with the assumptions in the model.

[3] The FIRR shows as an Excel error in the North because the grant would tilt Year 1 cashflows into positive territory.

Figure 3: CSA Financial IRR and NPV with GCF Grants (5-year period)

Central Plains					
GCF on-granting (THB)	7,000.0				
GCF on-granting (EUR)	189.2				
Additional CSA cashflows (THB/year)					
Without grant	(31,663.0)	11,001.8	11,001.8	10,880.2	10,641.7
Grant	7,000.0				
With grant	(24,663.0)	11,001.8	11,001.8	10,880.2	10,641.7
CSA IRR with grant (%)	**27.5%**				
CSA NPV with grant (THB)	**8,976.4**				

Northeast					
GCF on-granting (THB)	7,000.0				
GCF on-granting (EUR)	189.2				
Additional CSA cashflows (THB/year)					
Without grant	(19,243.2)	6,331.2	6,331.2	6,206.8	5,962.9
Grant	7,000.0				
With grant	(12,243.2)	6,331.2	6,331.2	6,206.8	5,962.9
CSA IRR with grant (%)	**36.2%**				
CSA NPV with grant (THB)	**6,800.7**				

North					
GCF on-granting (THB)	4,000.0				
GCF on-granting (EUR)	108.1				
Additional CSAcashflows (THB/year)					
Without grant	(2,215.2)	(183.7)	1,170.6	1,157.1	1,130.5
Grant	4,000.0				
With grant	1,784.8	(183.7)	1,170.6	1,157.1	1,130.5
CSA IRR with grant (%)	**#NUM!**				
CSA NPV with grant (THB)	**3,842.4**				

- Financial incentives will be discontinued once the GCF project expires. Since CSA produces a positive FIRR and NPV without incentives, once the initial risk aversion is overcome and farmers realise the financial benefits of the new technologies, it is expected that they will persist in their implementation. BAAC will be fully capacitated to evaluate the financial benefits of CSA and some farmers that were previously not eligible for BAAC loans may become so. In addition, as a result of Sub-Activity 3.1.2.3 (Carbon Market Linkages), progress will have been made towards the establishment of a voluntary carbon pricing mechanism that allows CSA farmers to at least partially monetise the carbon value of CSA adoption, adding to the financial attractiveness of CSA.

Hypothetical Concessional Loan Scenario

The GCF project will mobilise a substantial BAAC loan dedicated to CSA farmers and funded out of BAAC's existing balance sheet (with no need for a GCF concessional loan).

Still, hypothetically, we have run the scenario in which GCF lends at concessional terms to the Government of Thailand and the amount is on-lent by state-owned BAAC to CSA-adopting farmers that pass BAAC's credit screening. BAAC will not commit to specific loan terms now for a programme that is likely to start only next year. Hypothetically, we have assumed the following terms for BAAC's on-lending: (i) 5-year maturity with 1-year grace period; (ii) 4 equal instalments in Years 2-5; (iii) a conservative 5% interest rate, higher than GCF rates due to the cost of converting GCF hard currency into THB and BAAC's operating costs (it is possible that rates may be lower, as in other BAAC concessional lending programmes); and (v) a loan amount equal to 50% of the LLL service fee in the Central Plains and North-East and a small loan of THB 3,000 in the North where LLL is not implemented.

Unsurprisingly, FIRRs increase compared to the base case, no-grant scenario (see Figure 4), since the cost of debt is lower than the unlevered FIRRs shown above.[4]

It is worth noting that a loan, albeit at concessional terms, would hardly be considered a subsidy by risk-averse farmers who are new to CSA. Also, BAAC on-lending would only be available to creditworthy farmers – not to all farmers – and any relaxation of BAAC's standard credit approval criteria is unlikely to occur, as it would likely result in some farmers defaulting (making the loan *de facto* a grant).

Figure 4: FIRR Without Grant But With Concessional Loan

Central Plains					
Loan principal	17,582.4				
As % of LLL fee	50.0%				
Interest rate	5.0%				
Grace period	1 year				
Principal + accrued interest after 1yr	18,461.5				
Instalments in years 2-5	-	5,206.4	5,206.4	5,206.4	5,206.4
CSA cashflows without grant and with loan					
CSA cashflows without grant	(31,663.0)	11,001.8	11,001.8	10,880.2	10,641.7
Loan	17,582.4	(5,206.4)	(5,206.4)	(5,206.4)	(5,206.4)
CSA cashflows after loan	(14,080.6)	5,795.5	5,795.5	5,673.8	5,435.4
CSA IRR (no grant, with loan)	**22.5%**				

[4] The FIRR shows as an Excel error in the North because the loan would tilt Year 1 cashflows into positive territory.

Northeast					
Loan principal	12,787.2				
As % of LLL fee	50.0%				
Interest rate	5.0%				
Grace period	1 year				
Principal + accrued interest after 1yr	13,426.6				
Instalments in years 2-5	-	3,786.4	3,786.4	3,786.4	3,786.4
CSA cashflows without grant and with loan					
CSA cashflows without grant	(19,243.2)	6,331.2	6,331.2	6,206.8	5,962.9
Loan	12,787.2	(3,786.4)	(3,786.4)	(3,786.4)	(3,786.4)
CSA cashflows after loan	(6,456.0)	2,544.7	2,544.7	2,420.3	2,176.5
CSA IRR (no grant, with loan)	**19.0%**				

North					
Loan principal	3,000.0				
Interest rate	5.0%				
Grace period	1 year				
Principal + accrued interest after 1yr	3,150.0				
Instalments in years 2-5	-	888.3	888.3	888.3	888.3
CSA cashflows without grant and with loan					
CSA cashflows without grant	(2,215.2)	(183.7)	1,170.6	1,157.1	1,130.5
Loan	3,000.0	(888.3)	(888.3)	(888.3)	(888.3)
CSA cashflows after loan	784.8	(1,072.1)	282.3	268.7	242.2
CSA IRR (no grant, with loan)	**#NUM!**				

II. Economic Analysis

This section should be read in conjunction with the ‘EIRR’ sheet in the Excel model.

The main quantifiable economic benefits of the projects are: (i) the estimated GHG emission reductions resulting from adoption of CSA by the ~253,400 target beneficiaries; (ii) the increase in income from the adoption of CSA; and (iii) the value of water saved by the implementation of CSA. The three effects are discussed below.

<u>GHG Emission Reductions Estimate</u>

The estimated emission reductions for the project, discussed in detail in the analysis provided by IRRI (see Annex 22), is 12.6 million tCO_2eq over 15 years. The 15-year period is assumed to start in 2024 – the project is expected to begin in late 2023, but any activities conducted that year would be small and organisational in nature. The annual emission reductions will increase gradually from 2024 to 2028, when they are expected to reach ~1.0 $mtCO_2eq$.

The project assumes the continued implementation of CSA by all farmers, subject to the imposed cap of only 72% of their total land area being allocated to CSA.[5] This will result in an additional ~1.0 mtCO_2eq/year of emission reductions for the subsequent 10 years. The emission reductions will continue thereafter but, conservatively, estimates are limited to the 15-year period (5 project years + additional 10 years).

The base-case assumption chosen for the shadow price of carbon is EUR 60/tCO_2eq. The OECD has published a study on the effective carbon prices needed to meet the Paris Agreement's goal of limiting global temperature increases to 1.5°C by mid-century.[6] Based on a comprehensive review of studies by academic and policy institutions, the OECD has selected EUR 60 as its mid-range estimate of required carbon prices. The OECD's low-end estimate is EUR 30, while its high-end estimate is EUR 120. To put the OECD's mid-range estimate in context:

- The High-Level Commission on Carbon Prices estimates that carbon prices of EUR 40-80 were needed in 2020 for countries to decarbonise in line with the Paris Agreement. In 2030, prices should reach EUR 50-100.[7]

- The IMF recommends an increase in carbon prices by EUR 75 from current levels through 2030 in a scenario that assumes optimal support for clean technology development.[8]

- Emission allowances in the EU Emission Trading Scheme (EU-ETS), the world's largest, reached EUR 100 as of mid-February 2023.[9]

The OECD's mid-range estimate therefore appears reasonable and possibly even conservative in light of EU market prices.

<u>Incremental Income for CSA Farmers</u>

Consistent with the emission reductions estimate, ~253,400 farmers are expected to adopt CSA (on ~72% of their land on average, as discussed in the farm assumptions above). The pace of adoption mirrors that in the emission reduction estimate (cumulative adoption by 10% of the farmers in 2024, 20% in 2025, 40% in 2026, 70% in 2027 and 100% in 2028). Each farmer is assumed to repeat the CSA investment for a new 5-year cycle once the previous 5-year cycle has expired. In each 5-year cycle, a farmer realises the incremental cashflows shown in the FIRR calculation for the respective region.

Note that the financial incentive amount (GCF on-granting), which enters the EIRR calculation as a negative amount as part of the overall project budget, is added back as a separate line. This is because, at a societal level, this on-granting represents a

[5] It is expected that CSA will also be practised on at least some of the 28% of 'non-CSA' farmland, albeit in a less systematic, more ad hoc manner. For reasons of GHG accounting conservativeness, it is assumed that the 'non-CSA' farmland generates no emission reductions.
[6] OECD (2021). *Effective Carbon Rates 2021 – Pricing Carbon Emissions through Taxes and Emissions Trading*. Link: https://www.oecd-ilibrary.org/taxation/effective-carbon-rates-2021_0e8e24f5-en.
[7] Ibid.
[8] Ibid.
[9] Financial Times (21 February 2023). *EU carbon price tops €100 a tonne for first time*.

redistribution of income from GCF donors (global taxpayers) to the beneficiary Thai farmers and is therefore a 'wash' in the EIRR calculation.

Value of Water Saved

The total amount of water saved is estimated conservatively at 1.7 billion cubic meters, based on the following assumptions:

- Water saving technologies are primarily AWD and LLL. A study estimates the amount of water saved by AWD at 570 m3/ha/year.[10]
- AWD will be applied in the Central Plains and the North but not in the Northeast, where only LLL will be applied. Based on the area where CSA will be implemented in the Central Plains and the North, we have estimated the annual water saving volume and cumulative amount over 15 years.

A study estimates the shadow price of water saved through water-efficient rice farming, across a range of rice-farming countries, at USD 0.025/m3 (EUR 0.023/m3).[11] Based on this and the above volume estimate, an annual shadow value of water saved was estimated. This value is deemed as conservative because only AWD water savings were considered.

Base-Case Economic IRR and NPV

With the above assumptions and a total project budget of EUR 118 million (rounded) (GCF grant + co-finance), the GCF project yields an attractive economic IRR (EIRR) of ca. 37% and NPV of EUR 215 million (rounded). The economic NPV is based on a 10% discount rate, as customarily used in economic analyses.

Sensitivity Analysis

A sensitivity analysis indicates that the economic IRR and NPV are robust in downside scenarios. For the purpose of the sensitivity analysis, two variables have been considered: (i) lower carbon prices, down to an extremely conservative minimum of EUR 5/tCO_2eq, and (ii) a lower volume of emission reductions and lower incremental farm income from base-case, in 10% negative increments.

The analysis (see Figure 5 and 6) shows that the EIRR would be double-digit even if carbon prices dropped to EUR 20, below the OECD's low-end estimate, and the emission reductions volume / incremental income were 20% lower than in the base case. The latter extreme scenario could be the result of extreme weather events, such as large-scale

[10] Thapat Silalertruksa, Shabbir H. Gheewala, Rattanawan Mungkung, Pariyapat Nilsalab, Naruetep Lecksiwilai and Wanchat Sawaengsak (2017), *Implications of Water Use and Water Scarcity Footprint for Sustainable Rice Cultivation*.

[11] Marc F. P. Bierkens, Stijn Reinhard, Jens A. de Bruijn, Willeke Veninga, Yoshihide Wada (2019). The Shadow Price of Irrigation Water in Major Groundwater-Depleting Countries. Link: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018WR023086#:~:text=The%20following%20definition%20of%20shadow,e.g.%2C%20labor%20and%20fertilizer).

droughts, with devastating effects on farming activities. The EIRR would still be positive with an extremely low carbon price of EUR 5/tCO_2eq and emission reductions / incremental income in line with the base case estimate. The economic NPV would still be positive with a carbon price of EUR 20/tCO_2eq and 20% lower emission reductions / incremental income.

Figure 5: Economic IRR Sensitivity

		Change in emissions and income vs. base case			
		-30%	-20%	-10%	0%
	5	-2.3%	-1.3%	-0.4%	0.4%
	10	2.2%	3.4%	4.4%	5.4%
	15	6.0%	7.3%	8.5%	9.6%
	20	9.3%	10.8%	12.2%	13.3%
	25	12.4%	14.0%	15.5%	16.7%
Carbon	30	15.3%	17.0%	18.6%	19.9%
price	35	18.0%	19.9%	21.5%	23.0%
(EUR/t)	40	20.6%	22.6%	24.3%	25.9%
	45	23.1%	25.2%	27.1%	28.7%
	50	25.5%	27.7%	29.7%	31.4%
	55	27.8%	30.2%	32.3%	34.1%
	60	30.1%	32.6%	34.8%	36.7%

Figure 6: Economic NPV sensitivity

		Change in emissions and income vs. base case			
		-30%	-20%	-10%	0%
	5	(54.1)	(53.1)	(52.0)	(50.9)
	10	(37.3)	(33.8)	(30.3)	(26.8)
	15	(20.4)	(14.5)	(8.6)	(2.7)
	20	(3.5)	4.8	13.1	21.4
	25	13.4	24.1	34.8	45.6
Carbon	30	30.2	43.4	56.5	69.7
price	35	47.1	62.7	78.2	93.8
(EUR/t)	40	64.0	81.9	99.9	117.9
	45	80.9	101.2	121.6	142.0
	50	97.7	120.5	143.3	166.1
	55	114.6	139.8	165.0	190.2
	60	131.5	159.1	186.7	214.3