Intensification of Agriculture and Agroforestry Technologies (IAAT) for Climate Resilient Food and Nutrition Security: Tombouctou, Gao, Mopti, Koulikoro and Segou Regions of Mali

Annex 3: Economic and Financial Analyses

Accredited Entity: Save the Children Australia

Version: B.41 – 2025/01/21

INTRODUCTION

IAAT will support the Government of Mali to advance progress on its national climate change adaptation and mitigation priorities and commitments by increasing the climate resilience in agriculture systems and reducing greenhouse gas emissions. The Project will achieve this by working with government, civil society, the private sector, and communities to increase capacity and support climate risk-informed decisions, including scaling locally-led adaptation (LLA) actions to address vulnerability linked to food and water insecurity. The Project will focus on i) improving extension services for Climate Smart Agriculture (CSA) adoption, ii) supporting the development of CSA and agroforestry value chains, iii) reducing GHG emissions from agricultural systems, and iv) increasing institutional capacity and knowledge for climate action. Promoting CSA and agroforestry technologies will be the entry points for broader agroecological outcomes. The Project outcomes will cover climate change resilience, environmental health, gender equity, social inclusion, soil health, biodiversity conservation, and resource use efficiency, providing common points of reference for CSA and agroforestry. This project will be implemented in 5 regions (Gao, Koulikoro, Mopti, Segou, and Tombouctou) and 12 highly vulnerable circles covering 48 communes. The Project will establish circle-level LLA plan development committees composed of officials from the line ministries (e.g. agriculture, forestry, livestock, water, etc.) and representatives from the local government. The committees will provide input into LLA plans, approve activities, and monitor progress as the plans are implemented. The committees will also facilitate the integration of LLA plans into the government's local development programs. The Project will cover 460,965 direct beneficiaries, primarily smallholder farmers and youth and women agripreneurs, to increase their resilience to current and future climate change by building on-farm capacity and the supporting market and institutional environment for sustained adoption of climate-smart agriculture farming.

IAAT aims to achieve impact via four interlinked outcomes, each representing one Project component, with social, gender, economic, and environmental co-benefits anticipated. Each outcome is summarized below.

Component 1: Improving extension services and increasing on-farm CSA adoption – The activity aims to expand the reach of extension services and improve the adoption of climate-smart agriculture (CSA) and agroforestry practices among smallholder farmers. It involves developing a tailored curriculum for extension services to address climate risks and deliver productivity and resilience benefits. A "train the trainers" approach will refine public and private extension services, leveraging local organizations and digital platforms for broader reach. The focus is on the promotion and adoption of CSA and agroforestry practices among smallholder farmers by increasing their awareness, interest, and capacity through locally tailored training packages. Several channels will be leveraged to increase the potential to reach more farmers through extension services (including farmer field schools, and Rural Resource Centers (CRRs)). Additionally, technical support will be provided to local community organizations, benefiting an estimated 86,340 farming housholds in the targeted communes, with a gender-balanced approach. Furthermore, this activity aims for the adoption of regional land use mapping for agroforestry development and climate-smart agriculture (CSA) assisting with improving mapping land types, land-use planning, and decision-making at the commune level. A land-use database will be created to enhance extension services' knowledge for tailored farmer advisory

services and data also be shared with national authorities, benefiting regional and local authorities and public and private extension agents.

Component 2: Supporting the development of CSA and agroforestry value chains – The activity aims to improve accessibility and connectivity in value chains and fostering access to markets for smallholder farmers by leveraging digital marketplaces and existing innovation platforms, improving access to market information (e.g., prices) and fostering the development of a network of community-built service providers. Additionally, the activity seeks to enhance the capacity of targeted businesses and producer organizations to reach a larger market through the development and adoption of inclusive business models, capturing the needs of smallholder farmers, women, and youth. This activity also includes increased access to finance for smallholder farmers and/or agribusiness entrepreneurs by working directly with existing financial institutions to increase their reach as well as creating new Village Savings and Loans Associations (VSLAs) for women and youth. In addition, existing microfinance organizations active in CSA and agroforestry will be targeted to increase their reach by delivering investment guidelines that are inclusive of women and youth entrepreneurs and supporting the expansion of risk-adjusted lending (e.g., through the inclusion of crop and weather insurance in loan decisions).

This project will support the deployment of 1000 solar irrigation systems in two parts. First there is a small pilot phase which will install 50 large solar irrigation systems and 50 small solar irrigation systems, with 75% of the cost covered by the project and 25% covered by farmers. Secondly, there will be a deployment phase which will install 150 large solar irrigation systems, 230 medium solar irrigation systems and 520 small solar irrigation systems, with 15% of the cost covered by the project and 85% covered by farmers. The large systems cover 10 ha, the medium systems cover 5 ha and the small systems cover 1ha. As the systems cover a greater area than that typically farmed by small holder farmers, each system will serve more than one household. In all cases, these systems will replace existing diesel generator irrigation pumps resulting in GHG emissions reductions. In this Economic and Financial analysis, the deployment phase configuration has been used to model the provisional impact of this intervention, as this represents the majority of beneficiaries and impact. Additionally, the three value chains impacted by this intervention are mango, moringa and vegetables, with each value chain mapped to a specified solar irrigation system size.[1] This project will also partner with solar suppliers and financial institutions to scale up solar irrigation in Mali and deliver the solar pumping systems.

Component 3: Increasing institutional capacity and knowledge – This activity will work to strengthen the institutional capacities of government entities at the local, regional, and national level, as well as communities through Community Action Cycles (CACs), improving their adaptation planning capacities and management systems and procedures. At the local level it leverages the village level community action plans and the commune level Economic, Social, and Cultural Development Plans (PDESC) as the main entry points for improved adaptation planning. At the commune level, the activity provides tools for effective and timely review of community action plans to foster efficient management of local resources and inclusion of adaptation planning.

[1] For the EFA analysis the following mapping of value chains to solar irrigation systems has been used: Mango value chain beneficiaries will gain access to part of a large solar irrigation system, Moringa value chain beneficiaries will gain access to part of a medium solar irrigation system, Vegetable value chain beneficiaries will gain access to part of a small solar irrigation system.

Finally, knowledge-sharing and coordination of best practices is enhanced among relevant stakeholders which involves compiling the insights gained from the Project and disseminating to national and regional stakeholders, extending the reach of valuable knowledge and lessons learned. Component 3 will also enhance stakeholder collaboration for knowledge-sharing for scaling out CSA, enhancing the impacts and reach of the Component 1-3.

Overview of the Approach for Economic and Financial Analyses

We have carried out an economic and financial assessment, presented in the form of an integrated Cost Benefit Analysis (CBA). An integrated CBA is broad, as it includes indicators that are relevant to the projects (e.g. investment, O&M costs, revenue creation) -financial assessment - as well as to society, even if these are not directly connected to the investment and its performance (e.g., improvement of human health) - economic assessment.

The assessment includes the calculation of the financial Internal Rate of Return (IRR) and Net-Present Value (NPV). We also carry out an economic analysis, which includes the value of externalities. For this assessment, we consider investments in CSA and agroforestry technologies and also consider the impact of an investment over its lifetime of the technology use. Six investments have been analyzed. This analysis should be interpreted as indicative of the likely impacts of the project as designed; on the other hand, observed outcomes may differ from the estimates presented in this report. Figure 1 presents economic and financial analysis guidelines.

Figure 1: EFA guidelines for economic and financial analysis

Source: IFAD'S INTERNAL GUIDELINES- Economic and Financial Analysis of Rural Investment project-2019

An EFA appraisal is structured at two levels:

- Financial analysis at the farm level, where different types of households and livelihoods need to be considered and assessed. This analysis implies

calculating activity-/farm-based cash flows and incremental benefits in financial terms and identifying their specific financing needs.

- Economic analysis: A second key requirement is to use financial analysis as the base for the economic analysis. In this way, once the viability of proposed activities at the farm and enterprise level is ensured, consideration of a project's impact on the economy as a whole can be assessed.

How can a CBA ensure that the private and public dimensions are included and combined in the analysis?

The economic and financial analysis are elaborated from two different perspectives; the former has a broader social perspective, and the latter has a private-agent perspective. Investment decisions are driven by each agent's perspective. For example, the opportunity costs and the risks of the investment that each agent considers when assessing alternative investments are different.

Financial Analysis

This section explains how financial analysis assesses the project from a private perspective, which elements need to be considered, and how they are valued.

There are 4 key steps for a sound financial analysis:

1. Develop farm/enterprise models and identify benefits and costs (both investment and recurrent) for with- and without-project (WP and WOP) scenarios (based on crop budgets).
2. Compare the discounted flows of benefits and costs and calculate the differences between the results obtained and the WOP scenario to determine the net incremental benefits (NIBs) of the proposed interventions.
3. Calculate the project financial profitability indicators of each model – financial net present value (FNPV), financial internal rate of return (FIRR), return to family labour and benefit-cost ratio (BCR) – and apply these investment criteria to make an investment decision (positive or negative).
4. Assess family incomes and establish financing/credit needs by performing a sustainability analysis.

The cash flow analysis carried out at this stage assesses the profitability of the investments for the producer/ individual viewpoint and, at the same time, will be the starting point for the subsequent economic analysis. During these first steps of the EFA, the focus is on the financial performance of productive units (farms and businesses) run by project beneficiaries. The analysis will answer questions such as the following:

- Is this the best agricultural practice for the project-specific context?
- Are projects' improved practices financially viable?
- Is this a better solution than the actual/present practice?
- Are the new technologies and inputs required affordable and available?
- Are investment costs affordable and sustainable, or do they need to be covered by the project?

- Will farmers be able to implement new practices without project subsidies?

To reply to these and other relevant questions, the financial analysis should be based on accurate and detailed representations of beneficiaries' current common agricultural practices and proposed solutions. Let's then start with defining and developing the very first elements of the analysis.

The recommended tool for the description of beneficiaries' production functions is the formulation of farm models. The analysis develops a number of models that represent the production systems/ innovations introduced to the target population. The farm models replicate current production practices, which are then compared with project proposals to assess their viability. Farmers' production systems (i.e., the size of their plots, the distributions of crops and livestock, and the composition of their household) are reproduced by using crop models as the primary building blocks for farm models.

Crop models and farm models are composed of two important parts: (a) the technical and physical description of the activity; and (b) the financial budget, which presents cash inflows and outflows (i.e., crop budget).

Economic analysis

There are 5 steps for the Economic analysis:

1. Convert all market prices to economic prices that better reflect the social opportunity cost of the good and remove transfer payments (taxes and subsidies).
2. Quantify externalities (positive and negative).
3. Describe phasing patterns for beneficiaries' incorporation into project activities and aggregate farm/enterprise net incremental benefit cash flows.
4. Compare aggregated incremental benefits with economic project costs and discount final project cash flow, adopting a social discount rate to calculate economic performance indicators: economic net present value (ENPV), economic internal rate of return (EIRR), and BCR.
5. Perform sensitivity analysis to deal with the main risks and uncertainties that could affect the proposed project.

Economic analysis is performed from the perspective of the economy or society as a whole and is quite different from the perspective of the project beneficiaries – or individual entrepreneurs – that was used for the financial analysis. The two main aspects that differentiate economic from financial analysis are (a) the consideration of externalities, and (b) the use of economic prices that reflect the opportunity costs of goods and services for the country – usually different from their financial/market prices.

Project Specific Details for the Economic and Financial Appraisal (EFA)
The Economic and Financial Analysis of the project covers all main types of agriculture production currently targeted by the project, (i) cereals, (ii) mango, (iii)

moringa and (iv) vegetable production, (v) shea butter and (vi) arabic gum, with value chains ii-iv being developed in irrigated areas covered by new solar pumps.

Cash flow based Financial Analysis is done at the producer level and it creates the assessment of incremental financial income realized by the producer, financial return per day of labor, financial Internal rate of Return (FIRR), and financial Net present value using 10% as the discount rate (usual discount rate applied by IFAD / FAO in financial analysis at farm level in West Africa).

Economic analysis is done for the whole project. It is done using a social price for family labour, the societal benefit of the carbon emissions mitigated, and full project funding.

FINANCIAL ANALYSIS PER TYPE OF PRODUCTION AT THE PRODUCER LEVEL

This section includes the main outputs for the financial analysis conducted at the producer level for each value chain. Please note that further detailed information on the inputs for each value chain is provided in the associated EFA excel model.

Cereal millet producers applying CSA

There are 64,755 cereal producers targeted by the project to apply CSA-improved practices such as zai[6] pit, contour lines[7] with stone, compost application, and natural regeneration. These farmers have on average 0.5 ha of rainfed cereal currently yielding 700 kg per ha and have a critical yield increase potential estimated at 30% by the Albarka project and seen in previous studies.[8]

The financial analysis below focusses on the incremental cereal production covered by the deployment CSA practices. Based on 0.5 ha, it should reach 105 additional kg of cereal per farmer per year. Such an activity should allow USD 10 of additional cash flow per farmer per year which renumerates at USD 4.8 the additional day of labour. The Financial NPV is at USD 65 per farmer after costs provided by the project (support on CSA inputs).

Table 1: Incremental Cash Flow Analysis millet producer

Incremental Cash Flow analysis				with project activity								
Field Type	Field	Unit	without project	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9
Inputs required for production	Millet Seed Volume	# seedlings		33	33	33	33	33	33	33	33	33
Inputs required for production	Family Labour Volume	Days		4	3	4	4	4	4	4	4	4
Inputs required for production	Millet Seed Value	USD		3	3	3	3	3	3	3	3	3
Inputs required for production	Family Labour Value	USD		0	0	0	0	0	0	0	0	0
Inputs required for production	Fertilizer (manure) and pesticide value	USD		7	7	7	7	7	7	7	7	7
Inputs required for production	**Total Input Costs**	**USD**		**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**
Investment	**Total Cost Paid by Farmer**	**USD**		**3**	**3**	**3**	**3**	**3**	**11**	**11**	**11**	**11**
Investment	**Total Cost Paid by Project**	**USD**		**8**	**8**	**8**	**8**	**8**				
Output crop production	Incremental Millet Production Volume	KG		0	35	53	70	105	105	105	105	105
Output crop production	**Incremental Millet Production Value**	**USD**		**0**	**7**	**11**	**14**	**21**	**21**	**21**	**21**	**21**
Annual Cash Flow for Farmer before project investment				-11	-4	0	3	10	10	10	10	10
Annual Cash Flow for Farmer after project investment				-3	4	8	11	18	10	10	10	10
Return per day of work				0.0	2.1	2.3	3.5	4.8	4.8	4.8	4.8	4.8
IRR and NPV Outputs												
Without project investment												
Financial IRR at 10%				**34%**								
Financial NPV				**$ 34.95**								
With project investment												
Financial IRR at 10%				**220%**								
Financial NPV				**$ 65.39**								

Over 15 years, the IRR for the farmer after project investment is 220% based on the “most likely” scenario for key inputs (e.g. yield increase, price at which millet is sold). However, conducting a sensitivity analysis on the IRR after project investment shows the potential variation of the IRR based on changes in price obtained for the millet and millet’s yield, both of which are sensitive to the

ongoing climatic changes in Mali. Highlighting the importance of these variables, whilst keeping a fixed yield increase of 30%, the IRR varies from 168% to 272% based on a variable price of 0.16USD/kg to 0.24USD/kg. By contrast, whilst keeping a fixed price of 0.20 USD/kg, the IRR varies from 81% to 349% based on a variable yield increase of 15% to 45%.

Table 2: Sensitivity Analysis: impact of millet price and yield on farmer IRR

With Project Investment: IRR Sensitivity Analysis: Price vs Yield

		Yield Increase (%)						
Price (USD/kg)	220%	15.00%	20.00%	25.00%	30%	35.00%	40.00%	45.00%
	0.16	#NUM!	92%	132%	168%	203%	237%	272%
	0.17	13%	103%	143%	181%	218%	255%	291%
	0.18	4%	113%	155%	194%	233%	272%	311%
	0.19	71%	122%	166%	207%	248%	289%	330%
	0.2	81%	132%	177%	220%	263%	306%	349%
	0.21	90%	141%	188%	233%	278%	323%	369%
	0.22	98%	150%	199%	246%	293%	341%	388%
	0.23	105%	159%	209%	259%	308%	358%	407%
	0.24	113%	168%	220%	272%	323%	375%	427%

Mango producers

The project will support the rehabilitation of the plantation and the replacement of diesel pumps with large solar irrigation systems on 2,000 ha of mango trees for 2,857 producers. Every beneficiary will be supported to upgrade 0.7 ha of their plantation including at least partial financial support for PAYG solar irrigation and additional support for CSA related inputs (such as manure). A targeted mango yield of 16,000 kg/ha was provided by Ministère du Développement Rural, Plan Triennal de Campagne Agricole Consolidé et Harmonisé (2023). Data used in the financial analysis is also issued from a recent Mali mango value chain study[2] (2017) and a sub-regional FAO-IFAD study[3]. At the farm level, the FIRR is 134% due to reduced investment paid by farmers and the incremental Net present value is USD 5736.

[2] FRR-Volume-1-No-3_2017-Innovation-Opportunities-in-Mango-Value-Chain-in-Mali.pdf (faraafrica.org)

[3] Van Melle, C., and S. Buschmann (2013), Comparative analysis of Mango Value Chain models in Benin, Burkina Faso and Ghana, In: Rebuilding West Africa's Food Potential, A. Elbehri (ed.), FAO/IFAD.

Table 3: Incremental Cash Flow Analysis Mango producer

Incremental Cash Flow analysis												
				with project activity								
Field Type	**Field**	**Unit**	**without project**	**year 1**	**year 2**	**year 3**	**year 4**	**year 5**	**year 6**	**year 7**	**year 8**	
Inputs required for production	Mango Tree Seedling Volume	# seedlings		65								
Inputs required for production	Family Labour Volume (planting and then maintenance)	Days	70	75	75	90	95	95	95	95	95	
Inputs required for production	Mango Tree Seedling Value	USD		32.5								
Inputs required for production	Family Labour Value (planting and then maintenance)	USD	0	0	0	0	0	0	0	0	0	
Inputs required for production	Private Labour Value (additional to family labour, for planti	USD	0	45								
Inputs required for production	Cost of Diesel for Existing Irrigation	USD	280	280								
Inputs required for production	Other Inputs - Pesticide - Value	USD	10	20	63	63	63	63	63	63	63	
Inputs required for production	Solar Irrigation equipment cost	USD		439	439	439						
Inputs required for production	Solar Irrigation installation cost	USD		35								
Inputs required for production	**Total Input Costs**	**USD**	**290**	**851**	**502**	**502**	**63**	**63**	**63**	**63**	**63**	
Investment	**Total Cost Paid by Farmer**	**USD**	**290**	**585**	**439**	**439**	**0**	**0**	**63**	**63**	**63**	
Investment	**Total Cost Paid by Project**	**USD**		**266**	**63**	**63**	**63**	**63**				
Output crop production	Mango Production Volume	kg	7,000	7,000	8,400	10,080	11,200	11,200	11,200	11,200	11,200	
Output crop production	**Mango Production value**	**USD**	1400	1400	1680	2016	2240	2240	2240	2240	2240	
Annual Cash Flow for Farmer before project investment			1110	549	1178	1514	2177	2177	2177	2177	2177	
Incremental cash Flow before project investment				-561	68	404	1067	1067	1067	1067	1067	
Annual Cash Flow for Farmer after project investment			1110	815	1241	1577	2240	2240	2177	2177	2177	
Incremental cash Flow after project investment				-295	131	467	1130	1130	1067	1067	1067	
Return per day of family work after project investment					17	18	24	24	23	23	23	
Check: Total Cost = Cost from Project + Cost from Farmer				TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
IRR and NPV Outputs												
Without project investment												
Financial IRR at 10%				**81%**								
Financial NPV				**$ 5,312.81**								
With project investment												
Financial IRR at 10%				**134%**								
Financial NPV				**$ 5,735.59**								

Over 15 years, the IRR for the farmer after project investment is 134% based on the “most likely” scenario for key inputs (e.g. mango yield, price obtained per kg). However, conducting a sensitivity analysis on the IRR after project investment shows the potential variation of the IRR based on changes in price obtained for the mango/kg and the mango yield, both of which are sensitive to the ongoing climatic changes in Mali. Highlighting the importance of these variables, whilst keeping a fixed yield of 16,000 kg/ha, the IRR varies from 113% to 154% based on a variable price of 0.16 USD/kg to 0.24 USD/kg. By contrast, whilst keeping a fixed price of 0.20 USD/kg, the IRR varies from 119% to 146% based on a variable yield of 13,600kg /ha up to 18,400 kg/ha. When taking the lowest price and lowest yield modelled the IRR reaches 99%, whilst taking the highest price and yield modelled the IRR reaches 167%.

Table 4: Sensitivity Analysis: impact of mango price and yield on farmer IRR

With Project Investment: IRR Sensitivity Analysis: Price vs Yield

		Yield (kg / ha)						
Price (USD/kg)	134%	13,600	14,400	15,200	16,000	16,800	17,600	18,400
	0.16	99%	104%	109%	113%	117%	121%	125%
	0.17	104%	109%	114%	118%	122%	126%	130%
	0.18	109%	114%	119%	123%	128%	132%	135%
	0.19	114%	119%	124%	129%	133%	137%	141%
	0.20	119%	124%	129%	134%	138%	142%	146%
	0.21	124%	129%	134%	139%	143%	147%	151%
	0.22	128%	134%	139%	144%	148%	152%	157%
	0.23	133%	139%	144%	149%	153%	158%	162%
	0.24	138%	144%	149%	154%	158%	163%	167%

Moringa producers

The project will support the rehabilitation of the plantation and the replacement of diesel pumps with medium solar irrigation systems on 1150 ha of moringa for 2875 producers. Every beneficiary will be supported to upgrade 0.4 ha of their plantation including at least partial financial support for PAYG solar irrigation and additional support for CSA related inputs (such as manure).

Moringa positions on top of results in terms of financial return. It is a very intensive production which reaches 23 tons per ha irrigated. Every producer will generate an incremental cash flow of USD 855 per year. After including the project support, the FIRR reaches 233% with an NPV of USD 4962.

Table 6: Incremental cash follow analysis of Moringa producer

Incremental Cash Flow analysis											
				with project activity							
Field Type	**Field**	**Unit**	**without project**	**year 1**	**year 2**	**year 3**	**year 4**	**year 5**	**year 6**	**year 7**	**year 8**
Inputs required for production	Family Labour Volume (planting and then maintenance)	# days	60	80	100	124	124	124	124	124	124
Inputs required for production	Family Labour Value (planting and then maintenance)	USD	0	0	0	0	0	0	0	0	0
Inputs required for production	Cost of Diesel for Existing Irrigation	USD	160	160							
Inputs required for production	Seedling Value	USD		14							
Inputs required for production	Other Inputs Used (pesticide / compost)	USD	40	40	40	40	40	40	40	40	40
Inputs required for production	Solar Irrigation equipment cost	USD		320	320	320					
Inputs required for production	Solar Irrigation installation cost			40							
Inputs required for production	**Total Input Cost**	**USD**	**199.6**	**574**	**360**	**360**	**40**	**40**	**40**	**40**	**40**
Investment	**Total Cost Paid by Farmer**	**USD**	**199.6**	**386**	**322**	**322**	**2**	**2**	**40**	**40**	**40**
Investment	**Total Cost Paid by Project**	**USD**		**187**	**37**	**37**	**37**	**37**			
Output crop production	Total Volume of Moringa Produced	KG	6000	6000	8000	9200	9200	9200	9200	9200	9200
Output crop production	Total Volume of Moringa to be sold	KG	4800	4800	6800	7820	7820	7820	7820	7820	7820
Output crop production	**Total value of Moringa to be sold**	**USD**	**1104**	**1104**	**1564**	**1799**	**1799**	**1799**	**1799**	**1799**	**1799**
Annual Cash Flow for Farmer before project investment			904	530	1204	1439	1759	1759	1759	1759	1759
Incremental cash Flow before project investment				-374	300	535	855	855	855	855	855
Annual Cash Flow for Farmer after project investment			904	718	1242	1476	1796	1796	1759	1759	1759
Incremental cash Flow after project investment				-187	337	572	892	892	855	855	855
Return per day of work			15.1	9.0	12.4	11.9	14.5	14.5	14.2	14.2	14.2
Check: Total Cost = Cost from Project + Cost from Farmer			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
IRR and NPV Outputs											
Without project investment											
Financial IRR at 10%				125%							
Financial NPV				**$ 4,684.41**							
With project investment											
Financial IRR at 10%				233%							
Financial NPV				**$ 4,961.89**							

Over 15 years, the IRR for the farmer after project investment is 233% based on the “most likely” scenario for key inputs (e.g. moringa yield, price obtained for moringa per kg). However, conducting a sensitivity analysis on the IRR after project investment shows the potential variation of the IRR based on changes in price obtained for the moringa /kg and the moringa yield, both of which are sensitive to the ongoing climatic changes in Mali. Highlighting the importance of these variables, whilst keeping a fixed yield of 23,000 kg/ha, the IRR varies from 187% to 281% based on a variable price of 0.18 USD/kg to 0.28 USD/kg. By contrast, whilst keeping a fixed price of 0.23 USD/kg, the IRR varies from 194% to 267% based on a variable yield of 19,550kg /ha up to 26,450 kg/ha. When taking the lowest price and lowest yield modelled the IRR reaches 152%, whilst taking the highest price and yield modelled the IRR reaches 317%.

Table 7: Sensitivity Analysis: impact of Moringa price and yield on farmer IRR

With Project Investment: IRR Sensitivity Analysis: Price vs Yield

		Yield (kg / ha)						
Price (USD/kg)	233%	19,550	20,700	21,850	23,000	24,150	25,300	26,450
0.18	152%	164%	176%	187%	197%	207%	216%	
0.20	162%	175%	187%	198%	209%	219%	229%	
0.21	172%	186%	198%	210%	221%	231%	241%	
0.22	183%	197%	210%	222%	233%	244%	254%	
0.23	194%	208%	221%	233%	245%	256%	267%	
0.24	204%	219%	233%	245%	257%	268%	279%	
0.25	215%	230%	244%	257%	269%	281%	292%	
0.26	227%	242%	256%	269%	281%	293%	304%	
0.28	238%	253%	268%	281%	294%	306%	317%	

Vegetable Producers

The project will support the rehabilitation of the plantation and the replacement of diesel pumps with small solar irrigation systems on 570 ha of vegetables for 1,900 producers. Every beneficiary will be supported to upgrade 0.3 ha of their plantation including at least partial financial support for PAYG solar irrigation and additional support for CSA related inputs (such as manure). Vegetable production is very labour intensive with over 700 man-days mobilized per household over 5 years. Furthermore, fresh vegetable production is widely affected by pre- and post-harvest loss (15%).

Based only on marketed vegetables (excluding the value of the vegetables lost in “post-harvest loss”), the incremental financial cash flow rises to USD 426 per beneficiary per year. The IRR is at 246% while NPV is around USD 2540.

Table 5: Incremental cash follow analysis of Vegetable producer

Incremental Cash Flow analysis										
				with project activity						
Field Type	**Field**	**Unit**	**without project**	**year 1**	**year 2**	**year 3**	**year 4**	**year 5**	**year 6**	**year 7**	**year 8**
Inputs required for production	Family Labour Volume (planting and then maintenance)	Days	110	110	132	158.4	158.4	158.4	158.4	158.4	158.4
Inputs required for production	Family Labour Value	USD	0	0	0	0	0	0	0	0	0
Inputs required for production	Seedling Value	USD		27	27	27	27	27	27	27	27
Inputs required for production	Other Inputs - Compost - Value	USD		33	33	33	33	33	33	33	33
Inputs required for production	Other Inputs - Pesticide - Value	USD		7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Inputs required for production	Cost of Diesel for Existing Irrigation	USD	120	120							
Inputs required for production	Solar Irrigation equipment cost	USD		110	110	110					
Inputs required for production	Solar Irrigation installation cost			0							
Inputs required for production	**Total Input Cost**	**USD**	**120**	**297.5**	**177.5**	**177.5**	**67.5**	**67.5**	**67.5**	**67.5**	**67.5**
Investment	**Total Cost Paid by Farmer**	**USD**	**120**	**202**	**132**	**132**	**22**	**22**	**68**	**68**	**68**
Investment	**Total Cost Paid by Project**	**USD**		**95**	**46**	**46**	**46**	**46**			
Output crop production	Total Vegetable Production Volume (before post harvest l	KG	2800	2800	3500	4710	4710	4710	4710	4710	4710
Output crop production	Total Vegetable Production Volume Possible to be Sold	KG	2,380	2,380	2,975	4,004	4,004	4,004	4,004	4,004	4,004
Output crop production	**Total Vegetable Production Value Possible to b**	**USD**	**547.40**	**547.40**	**684.25**	**920.81**	**920.81**	**920.81**	**920.81**	**920.81**	**920.81**
Annual Cash Flow for Farmer before project investment			427	250	507	743	853	853	853	853	853
Incremental cash Flow before project investment				-178	79	316	426	426	426	426	426
Annual Cash Flow for Farmer after project investment			427.40	345.15	552.50	789.06	899.06	899.06	853.31	853.31	853.31
Incremental cash Flow after project investment				-82	125	362	472	472	426	426	426
Return per day of work			-	1.3	1.1	0.4	0.3	0.3	0.4	0.4	0.4
Check: Total Cost = Cost from Project + Cost from Farmer			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
IRR and NPV Outputs											
Without project investment											
Financial IRR at 10%				**119%**							
Financial NPV				**$ 2,321.86**							
With project investment											
Financial IRR at 10%				**246%**							
Financial NPV				**$ 2,540.29**							

Over 15 years, the IRR for the farmer after project investment is 246% based on the “most likely” scenario for key inputs (e.g. vegetable yield, price obtained for vegetables per kg). However, conducting a sensitivity analysis on the IRR after project investment shows the potential variation of the IRR based on changes in price obtained for the vegetables /kg and the vegetable yield, both of which are sensitive to the ongoing climatic changes in Mali. Highlighting the importance of these variables, whilst keeping a fixed yield of 15,700 kg/ha, the IRR varies from 207% to 284% based on a variable price of 0.18 USD/kg to 0.28 USD/kg. By contrast, whilst keeping a fixed price of 0.23 USD/kg, the IRR varies from 205% to 281% based on a variable yield of 13,345kg /ha up to 18,055 kg/ha. When taking the lowest price and lowest yield modelled the IRR reaches only 171%, whilst taking the highest price and yield modelled the IRR reaches 322%.

Table 5: Sensitivity Analysis: impact of vegetable price and yield on farmer IRR

With Project Investment: IRR Sensitivity Analysis: Price vs Yield

		Yield (kg / ha)						
Price (USD/kg)	246%	13,345	14,130	14,915	15,700	16,485	17,270	18,055
0.18	171%	184%	196%	207%	218%	228%	238%	
0.20	180%	193%	205%	217%	228%	239%	249%	
0.21	188%	202%	215%	227%	238%	249%	260%	
0.22	197%	211%	224%	236%	248%	259%	270%	
0.23	205%	220%	233%	246%	258%	270%	281%	
0.24	214%	228%	242%	256%	268%	280%	291%	
0.25	222%	237%	252%	265%	278%	290%	302%	
0.26	230%	246%	261%	275%	288%	300%	312%	
0.28	239%	255%	270%	284%	297%	310%	322%	

Shea Butter producers

The project targets to support the shea butter value chain by improving shea agroforestry of 10,793 ha (50% of improved agroforestry areas) and implemented by an estimated 43,170 producers (half of the agroforestry producers) with 0.25 ha planted by each producer. Shea butter yield of 60 kg/ha is provided by Ministère du Développement Rural, Plan Triennal de Campagne Agricole Consolidé et Harmonisé (2023)

The data used in the analysis was issued from recent value chain studies in the region from FAO and Global Shea Alliance[4]. The analysis below targets the improved agroforestry practices by beneficiaries (on 0.25 ha) whose production will need about 10 years to reach 15 kg per producer. Annual cash flow will reach USD 22 by year 10. Shea's FIRR is around 66% with an NPV of USD 51.

Table 8: Incremental cash follow analysis of Shea producer

Incremental Cash Flow analysis												
				with project activity								
Field Type	Field	Unit	without project	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Inputs required for production	Shea Seedling Volume	# seedlings		26.3									
Inputs required for production	Family Labour Volume	Days		7.9	0.7	0.7	0.7	1.1	1.6	1.6	2.0	2.6	2.9
Inputs required for production	Shea Seedling Value	USD		5.3									
Inputs required for production	Family Labour Value	USD		-	-	-	-	-	-	-	-	-	-
Inputs required for production	Other Inputs (manure) Value	USD		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Inputs required for production	**Total Input Costs**	**USD**		**6.0**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**
Investment	**Total Cost Paid by Farmer**	**USD**		**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**
Investment	**Total Cost Paid by Project**	**USD**		**5.3**	-	-	-	-					
Output crop production	Incremental Shea Butter Production Volume	KG					0.7	1.2	1.9	3.2	5.4	9.0	15.0
Output crop production	**Incremental Shea Butter Production Value**	**USD**		-	-	-	**1.0**	**1.7**	**2.9**	**4.9**	**8.1**	**13.5**	**22.5**
Annual Cash Flow for Farmer before project investment				- 6	- 1	- 1	0	1	2	4	7	13	22
Annual Cash Flow for Farmer after project invetment				- 1	- 1	- 1	0	1	2	4	7	13	22
Return per day of work				- 0.1	- 1.2	- 1.2	0.4	0.9	1.3	2.6	3.7	4.8	7.5
Check: Total Cost = Cost from Project + Cost from Farmer				TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
IRR and NPV Outputs													
Without project investment													
Financial IRR at 10%				**38%**									
Financial NPV				**$ 46.23**									
With project investment													
Financial IRR at 10%				**66%**									
Financial NPV				**$ 51.01**									

Over 15 years, the IRR for the farmer after project investment is 66% based on the “most likely” scenario for key inputs (e.g. shea yield, price obtained for shea per kg). However, conducting a sensitivity analysis on the IRR after project investment shows the potential variation of the IRR based on changes in price obtained for the shea /kg and the shea yield, both of which are sensitive to the ongoing climatic changes in Mali. Highlighting the importance of these variables, whilst keeping a fixed yield of 60 shea butter kg/ha, the IRR varies from 59% to 71% based on a variable price of 1.2 USD/kg to 1.8 USD/kg. By contrast, whilst keeping a fixed

[4] source: Bockel, L., Veyrier, M., Gopal, P., Adu, A. and Ouedraogo, A. 2020. Shea value chain as a key pro-poor carbon fixing engine in West Africa. Accra. FAO and Global Shea Alliance https://globalshea.com/gsamain/storage/img/marqueeupdater/2020.05.27.09.41GSA%20FAO%20REPORT.pdf

price of 1.5 USD/kg, the IRR varies from 61% to 70% based on a variable yield of 51 kg/ha up to 69 kg/ha. When taking the lowest price and lowest yield modelled the IRR reaches 54%, whilst taking the highest price and yield modelled the IRR reaches 76%.

Table 9: Sensitivity Analysis: impact of shea price and yield on farmer IRR

With Project Investment: IRR Sensitivity Analysis: Price vs Yield								
		Yield (kg / ha)						
Price (USD/kg)	66%	51	54	57	60	63	66	69
	1.2	54%	56%	57%	59%	60%	62%	63%
	1.3	56%	58%	59%	61%	62%	64%	65%
	1.4	58%	59%	61%	62%	64%	65%	67%
	1.4	59%	61%	62%	64%	65%	67%	68%
	1.5	61%	62%	64%	66%	67%	69%	70%
	1.6	62%	64%	65%	67%	69%	70%	72%
	1.7	64%	65%	67%	69%	70%	72%	73%
	1.7	65%	67%	68%	70%	72%	73%	75%
	1.8	66%	68%	70%	71%	73%	75%	76%

Arabic Gum producers

The project targets to support the arabic gum value chain by the improvement of arabic gum agroforestry of 10,793 ha (50% of improved agroforestry areas) and implemented by an estimated 43,170 producers (half of the agroforestry producers) with 0.25 ha planted by each producer. The analysis below targets the improved agroforestry practices by beneficiaries (on 0.25 ha) whose production will need about 9 years to reach 45 kg per producer.

The gum Arabic production is sold at the producer level for around USD 1 per kg. On 0.25 ha of Arabic gum, the farmer will make an annual cash flow of USD 44 by year 9. The Financial IRR is at 130% and the NPV is USD 146, after including the project investment.

Table 10: Incremental cash flow analysis of Arabic Gum producers

Incremental Cash Flow analysis												
				with project activity								
Field Type	**Field**	**Unit**	**without project**	**year 1**	**year 2**	**year 3**	**year 4**	**year 5**	**year 6**	**year 7**	**year 8**	**year 9**
Inputs required for production	Arabic Gum Seedling Volume	# seedlings		26								
Inputs required for production	Family Labour Volume (planting and then maintenance)	Days		7	1	1	1	1	2	3	4	5
Inputs required for production	Arabic Gum Seedling Value	USD		8								
Inputs required for production	Family Labour Value	USD		0	0	0	0	0	0	0	0	0
Inputs required for production	Other Inputs (manure) Value	USD		1	1	1	1	1	1	1	1	1
Inputs required for production	**Total Input Costs**	**USD**		**9**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Investment	**Total Cost Paid by Farmer**	**USD**	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Investment	**Total Cost Paid by Project**	**USD**		**8**	**0**	**0**	**0**	**0**				
Output crop production	Incremental Arabic Gum Production Volume	kg					5	9	18	27	36	45
Output crop production	**Incremental Arabic Gum Production value**	**USD**		**0**	**0**	**0**	**5**	**9**	**18**	**27**	**36**	**45**
Annual Cash Flow for Farmer before project investment				-9	-1	-1	4	8	17	26	35	44
Annual Cash Flow for Farmer after project invetment				-1	-1	-1	4	8	17	26	35	44
Return per day of work				- 0.1	- 0.6	- 1.2	6.4	7.8	9.4	7.7	8.9	9.6
Check: Total Cost = Cost from Project + Cost from Farmer				TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
IRR and NPV Outputs												
Without project investment												
Financial IRR at 10%				**60%**								
Financial NPV				**$ 138.85**								
With project investment												
Financial IRR at 10%				**130%**								
Financial NPV				**$ 146.02**								

Over 15 years, the IRR for the farmer after project investment is 130% based on the “most likely” scenario for key inputs (e.g. Arabic gum yield, price obtained for Arabic gum per kg). However, conducting a sensitivity analysis on the IRR after project investment shows the potential variation of the IRR based on changes in price obtained for the Arabic gum /kg and the Arabic gum yield, both of which are sensitive to the ongoing climatic changes in Mali. Highlighting the importance of these variables, whilst keeping a fixed yield of 180 arabic gum kg/ha, the IRR varies from 118% to 141% based on a variable price of 0.8 USD/kg to 1.2 USD/kg. By contrast, whilst keeping a fixed price of 1.0 USD/kg, the IRR varies from 124% to 136% based on a variable yield of 153 kg/ha up to 207 kg/ha. When taking the lowest price and lowest yield modelled the IRR reaches 112%, whilst taking the highest price and yield modelled the IRR reaches 147%.

Table 10: Sensitivity Analysis: impact of shea price and yield on farmer IRR

With Project Investment: IRR Sensitivity Analysis: Price vs Yield								
		Yield (kg / ha)						
Price (USD/kg)	130%	153	162	171	180	189	198	207
	0.8	112%	114%	116%	118%	120%	122%	123%
	0.9	115%	117%	119%	121%	123%	125%	127%
	0.9	118%	120%	122%	124%	126%	128%	130%
	1.0	121%	123%	125%	127%	129%	131%	133%
	1	124%	126%	128%	130%	132%	134%	136%
	1.1	127%	129%	131%	133%	135%	137%	139%
	1.1	129%	132%	134%	136%	138%	140%	142%
	1.2	132%	134%	136%	139%	141%	143%	145%
	1.2	135%	137%	139%	141%	143%	145%	147%

Summary of financial analysis

Table 7 presents a summary of the financial analysis of products. The vegetable value chain has the highest financial IRR at 10% (246%) and the lowest financial IRR is Shea butter production (66%). However the financial NPV is highest for Mango production (USD 5736) whilst Shea Butter has the lowest financial NPV (USD 51).

Table 7: Summary of financial analysis of 7 economic products

Value Chain	IRR (with project support)	NPV (USD) (with project support)
CSA mil/maize producers with increased yield due to CSA techniques	220%	65
Mango - addition of CSA techniques & swapping diesel to large solar irrigation systems	134%	5,736
Moringa - addition of CSA techniques & swapping diesel to medium solar irrigation systems	233%	4,962
Vegetable - addition of CSA techniques & swapping diesel to small solar irrigation systems	246%	2,540
Shea Butter – improved agroforestry	66%	51
Arabic Gum – improved agroforestry	130%	146

The financial analysis results show a strong financial return profile for the farmers after project support, showing the compelling financial case for delivering the project's activities. Included in the accompanying financial analysis excel is a modelled scenario of financial return without project investment which also in some cases presents a strong return over 15 years. However, a number of challenges within the financial profile make grant funding more relevant for the project than other financial instruments. Importantly, the return profile of the value chains often shows long periods to generate a positive return, for example many of the value chains modelled do not generate a positive return until after 3 years of project implementation. Access to finance is also highly limited in the areas in which the project is planned for implementation. The limited historical financial institutions have been further undermined by the national and local conflict context, which has led to the closure of banks on multiple occasions during the last decade. Additionally, as shown by the sensitivity analysis, the returns profile remains uncertain for farmers. The modelled variation in two key inputs (price obtained for crops and yield of crops) shows a significant range in the potential return for farmers, with uncertainties in climate as well as political and security context resulting in a wide range of potential return scenarios.

ECONOMIC ANALYSIS AT THE PROJECT LEVEL

For moving from the preceding financial analysis at the producer level (micro-level) developed in 3.2.1 to an economic analysis at the project level (project analysis), the following steps have been taken:

- to Multiply the cashflow per producer by the number of producers involved in every production.,
- to value the family labour; it is done by using a social price/ opportunity price per day of labour: USD 1.5 / day for all value chains
- other costs included in the financial analysis (agricultural inputs and solar pumps) have been assessed to reflect the true value of the goods, and so have not required updates to convert from financial to economic prices (see note below for more detail)

The total area covered by the modelled value chains is 57,683 with an aggregated public investment of USD $43.7 million. In the economic analysis, the implementation has been modelled so that implementation will be progressive and the coverage of all the producers will only be reached by year 3. In year 1, the project will start with millet/maize, Mango, vegetable, and moringa producers while years 2 and 3 will expand to include the improvements in agroforestry, accounting for the ramp-up time to create the agroforestry nurseries. The phasing of producers modelled in the analysis is provided in the table below.

A total of 86,340 beneficiaries are considered, with an overlap anticipated across beneficiaries of different value chains.

Table 8: Number of farmers accounted for project economic analysis

		total producers targetted	total area (Ha)
CSA mil/maize producers with increased yield due to CSA techniques	all yr 1	64,755	32,378
Mango - addition of CSA techniques & swapping diesel to large solar irrigation systems	all yr 1	2,857	2,000
Moringa - addition of CSA techniques & swapping diesel to medium solar irrigation systems	all yr 1	2,875	1,150
Vegetable - addition of CSA techniques & swapping diesel to small solar irrigation systems	all yr 1	1,900	570
Shea Butter - improved agroforestry, incremental benefits	(yr 2 to yr 3)	43,170	10,793
Arabic Gum - improved agroforestry, incremental benefits	(yr 2 to yr 3)	43,170	10,793
Total			*57,683*

Table 9: Phasing of farmers' coverage year per year

	phased implementation	(nb new farmers covered per year)				
	year 1	year 2	year 3	year 4	year 5	Total
CSA mil/maize producers with increased yield due to CSA techniques	64,755					64,755
Mango - addition of CSA techniques & swapping diesel to large solar irrigation systems	2,857					2,857
Moringa - addition of CSA techniques & swapping diesel to medium solar irrigation systems	2,875					2,875
Vegetable - addition of CSA techniques & swapping diesel to small solar irrigation systems	1,900					1,900
Shea Butter - improved agroforestry, incremental benefits		21,585	21,585			43,170
Arabic Gum - improved agroforestry, incremental benefits		21,585	21,585			43,170
total	**72,387**	**43,170**	**43,170**			

Economic Analysis based on incremental Economic activities (IRR, NPV)

This economic analysis is based on cash flow analysis with a project investment of USD 43.7 million and Economic return of agriculture productions as benefit.

The project budget of USD 43.7 million is distributed between year 1 and year 5 (16% in year 1, 24% in year 2, 24% in year 3, 20% in year 4, and 16% in year 5). It results in an Economic Net Present Value (ENPV) of USD 4.4 million and an Economic

Internal rate of return (EIRR) of 12% without valuing the economic value of GHG mitigated by the project.

Table 10: Economic cash flow analysis with project investment

Economic cash flow analysis (US$)	Total	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8
Public Investment	43,630,754	7,101,645	10,415,799	10,425,884	8,912,285	6,775,141			
Economic value of GHG per year	-	-	-	-	-	-	-	-	-
Cumulative Value chain cash flow for farmers									
CSA millmaize producers with increased yield due to CSA techniques		- 561,885	- 43,845	150,420	344,685	765,593	245,529	245,529	245,529
Mango - addition of CSA techniques & swapping diesel to large solar irrigation systems		- 865,078	353,933	1,249,648	3,121,286	3,121,286	2,941,429	2,941,429	2,941,429
Moringa - addition of CSA techniques & swapping diesel to medium solar irrigation systems		- 623,553	797,065	1,368,040	2,288,040	2,288,040	2,180,975	2,180,975	2,180,975
Vegetable - addition of CSA techniques & swapping diesel to small solar irrigation systems		- 156,275	174,990	549,205	758,205	758,205	671,280	671,280	671,280
Shea Butter - improved agroforestry, incremental benefits			- 272,306	- 310,599	- 76,586	- 53,927	- 28,926	- 18,427	31,692
Arabic Gum - improved agroforestry, incremental benefits			- 229,758	- 289,325	- 97,860	31,339	212,840	455,152	767,096
Economic Net Income		- 9,308,436	- 9,635,719	- 7,708,495	- 2,574,515	135,394	6,223,126	6,475,937	6,838,000
IRR		**12%**							
NPV		**$ 4.42 million US$**							

The NPV determines the present value of net benefits by discounting the streams of benefits and costs back to the beginning of the base year. These results do not include the economic co-benefits due to the reduction of GHG emissions.

Analysis combining additional production and Eco value of GHG impact at USD30 per tCO2

The economic public value of the negative carbon balance (reduction of GHG emissions) generated by the project is estimated at USD 4.9 million per year when using USD 30 as the social price for one ton of CO2. Accounting for both additional production and GHG co-benefits, the economic NPV reaches USD 31.5 million while the Economic IRR is up to 26%.

Table 11: Economic cash flow analysis combining additional production and eco value of GHG impact.

	Total	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8
Public Investment	43,630,754	7,101,645	10,415,799	10,425,884	8,912,285	6,775,141			
Economic value of GHG per year	4,893,086		1,467,926	2,446,543	3,425,160	4,893,086	4,893,086	4,893,086	4,893,086
Cumulative Value chain cash flow for farmers									
CSA millmaize producers with increased yield due to CSA techniques		- 561,885	- 43,845	150,420	344,685	765,593	245,529	245,529	245,529
Mango - addition of CSA techniques & swapping diesel to large solar irrigation systems		- 865,078	353,933	1,249,648	3,121,286	3,121,286	2,941,429	2,941,429	2,941,429
Moringa - addition of CSA techniques & swapping diesel to medium solar irrigation systems		- 623,553	797,065	1,368,040	2,288,040	2,288,040	2,180,975	2,180,975	2,180,975
Vegetable - addition of CSA techniques & swapping diesel to small solar irrigation systems		- 156,275	174,990	549,205	758,205	758,205	671,280	671,280	671,280
Shea Butter - improved agroforestry, incremental benefits			- 272,306	- 310,599	- 76,586	- 53,927	- 28,926	- 18,427	31,692
Arabic Gum - improved agroforestry, incremental benefits			- 229,758	- 289,325	- 97,860	31,339	212,840	455,152	767,096
Economic Net Income		- 9,308,436	- 8,167,793	- 5,261,952	850,645	5,028,480	11,116,212	11,369,023	11,731,086
IRR		**26%**							
NPV		**$ 31.51 million US$**							

Simulation of Global Economic analysis using the social price of USD 60 per TCOe mitigated

The numerical values of the social value of carbon recommended for use by the World Bank Group in USD per 1 metric tonne of CO2 equivalent, are ranging between USD 20 (low) and USD 60 (high) in 2020 and increase to a range of USD 40-120 in real terms by 2040[5]. On this basis, it is relevant to propose a simulation of economic analysis with a higher social price per TCO2e of USD 60. Using this price, the GHG benefits are priced at USD 9.8 million. The analysis below now provides an EIRR of up to 39% and an ENPV of over USD 58.6 million on the next 15 years (2025-2040).

[5] https://www.worldbank.org/en/results/2017/12/01/carbon-pricing

Table 12: Economic cash flow analysis using the social price

	Total	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8
Public Investment	43,630,754	7,101,645	10,415,799	10,425,884	8,912,285	6,775,141			
Economic value of GHG per year	9,786,172		2,935,851	4,893,086	6,850,320	9,786,172	9,786,172	9,786,172	9,786,172
Cumulative Value chain cash flow for farmers									
CSA millmaize producers with increased yield due to CSA techniques		- 561,885	- 43,845	150,420	344,685	765,593	245,529	245,529	245,529
Mango - addition of CSA techniques & swapping diesel to large solar irrigation systems		- 865,078	353,933	1,249,648	3,121,286	3,121,286	2,941,429	2,941,429	2,941,429
Moringa - addition of CSA techniques & swapping diesel to medium solar irrigation systems		- 623,553	797,065	1,368,040	2,288,040	2,288,040	2,180,975	2,180,975	2,180,975
Vegetable - addition of CSA techniques & swapping diesel to small solar irrigation systems		- 156,275	174,990	549,205	759,205	759,205	671,280	671,280	671,280
Shea Butter - improved agroforestry, incremental benefits			- 272,306	- 310,599	- 76,586	- 53,927	- 28,926	- 18,427	31,692
Arabic Gum - improved agroforestry, incremental benefits			- 229,758	- 289,325	- 97,860	31,339	212,840	455,152	767,096
Economic Net Income		- 9,308,436	- 6,699,868	- 2,815,409	4,275,805	9,921,566	16,009,298	16,262,109	16,624,172

IRR	**39%**	
NPV	**$ 58.6**	**million US$**

Note on Conversion Factors for Financial and Economic Prices

Relevant conversion factors (from financial to economic prices) were considered for inclusion for each of the key inputs for the economic analysis. With the exception of labour costs, key inputs costs used in the financial analysis are considered to be a good representation of the true value of the goods meaning that conversion factors are not required. Each of the main categories of input costs (labour, agricultural, solar irrigation pumps) are outlined below with the relevant information:

- For labour, the value was converted between the financial and economic analysis based on the opportunity cost of labour. Monetary value was attributed to the labour days worked in the economic analysis (to reflect the true value and opportunity cost of the labour) at a rate of 1.5 USD/day whilst it was priced at 0 USD/day in the financial analysis as the labour is not financially compensated.
- For the main agricultural inputs, (such as seeds, seedlings or fertilizer in the form of manure), financial prices were instead deemed relevant for the economic analysis as they are considered to reflect the true value of the goods. These inputs are sourced from a local, informal economy and the relevant smallholder farmer beneficiaries are located in remote and hard to reach locations. As a result, the inputs are not subject to taxes, subsidies or other price distortions.
- The financial costs for the solar irrigation pumps are also considered to represent the goods' true value. Although solar irrigation pumps are reliant on international imports which often indicates the need for conversion factors, the Malian government introduced an import tax and VAT exemption for renewable energy equipment (including solar irrigation pumps) to support the transition to renewable energy from 2020.[6] It is also understood that end-user subsidies for equipment of this nature are not common, with support for purchasing costs instead provided by development actors (such as the IAAT project). As a result, the financial cost is understood to reflect the economic value.

CONCLUSION

The financial analysis of products shows that the Vegetables has the highest financial IRR at 10% (246%) and the lowest financial IRR is Shea butter production (66%). However, the financial NPV is highest for Mango production (USD 5,736) whilst shea butter production has the lowest financial NPV (USD 51). This financial analysis indicates the use of IRR and NPV for best business decisions and the selection of CSA technologies for cost minimization as well as increased production.

[6] https://www.droit-afrique.com/uploads/Mali-Ordonnance-2020-12-exoneration-tva-equipements-energies.pdf

The economic analysis is based on a cumulated cost-benefit analysis based on project investment of USD 43.7 million and Economic return of agriculture productions of beneficiaries per value chain as a benefit. It does result in an Economic Net Present Value (ENPV) of USD 4.4 million and an Economic Internal rate of return (EIRR) of 12% without valuing the Economic value of GHG mitigated by the project.

If the economic value of GHG mitigation is accounted for, the economic public value of the negative carbon balance (reduction of GHG emissions) generated by the project is estimated at USD 4.9 million per year when using USD 30 as the social price for one ton of CO2. Accounting for both additional production and GHG co-benefits, the economic NPV reaches USD 31.5 million while the Economic IRR is up to 26%. Within the simulation of economic analysis with a higher social price per TCO2e of USD 60 (leveraging World Bank group social price estimates), the analysis now provide an EIRR of up to 39% and an ENPV over USD 58.6 million.

ANNEX 1: EFA MATRIX ECONOMIC ANALYSIS WITH GHG IMPACT VALUED

		total producers targetted	total area (Ha)
CSA mil/maize producers with increased yield due to CSA techniques	all yr 1	64,755	32,378
Mango - addition of CSA techniques & swapping diesel to large solar irrigation systems	all yr 1	2,857	2,000
Moringa - addition of CSA techniques & swapping diesel to medium solar irrigation systems	all yr 1	2,875	1,150
Vegetable - addition of CSA techniques & swapping diesel to small solar irrigation systems	all yr 1	1,300	570
Shea Butter - improved agroforestry, incremental benefits	(yr 2 to yr 3)	43,170	10,793
Arabic Gum - improved agroforestry, incremental benefits	(yr 2 to yr 3)	43,170	10,793
Total			*57,685*

	phased implementation year 1	year 2	year 3	year 4	year 5	Total
	(nb new farmers covered per year)					
CSA mil/maize producers with increased yield due to CSA techniques	64,755					64,755
Mango - addition of CSA techniques & swapping diesel to large solar irrigation systems	2,857					2,857
Moringa - addition of CSA techniques & swapping diesel to medium solar irrigation systems	2,875					2,875
Vegetable - addition of CSA techniques & swapping diesel to small solar irrigation systems	1,300					1,300
Shea Butter - improved agroforestry, incremental benefits		21,585	21,585			43,170
Arabic Gum - improved agroforestry, incremental benefits		21,585	21,585			43,170
total	**72,387**	**43,170**	**43,170**			

price/tco2	60	US$/tCO2e
GHG red/yr	163,103	TCO2e mitigated per year
Eco Value	9.79	million USD

	Total	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15
Public investment	43,630,754	7,101,645	10,415,789	10,425,884	8,912,285	6,775,141										
Economic value of GHG per year	3,786,172		2,835,851	4,880,086	6,850,320	9,786,172	9,786,172	9,786,172	9,786,172	9,786,172	9,786,172	9,786,172	9,786,172	9,786,172	9,786,172	9,786,172
Cumulative Value chain cash flow for farmers																
CSA mil/maize producers with increased yield due to CSA techniques		- 561,885	- 43,845	150,420	344,685	765,593	245,529	245,529	245,529	245,529	245,529	245,529	245,529	245,529	245,529	245,529
Mango - addition of CSA techniques & swapping diesel to large solar irrigation systems		- 865,078	353,953	1,243,648	3,121,286	3,121,286	2,941,429	2,941,429	2,941,429	2,941,429	2,941,429	2,941,429	2,941,429	2,941,429	2,941,429	2,941,429
Moringa - addition of CSA techniques & swapping diesel to medium solar irrigation systems		- 623,553	797,065	1,368,040	2,288,040	2,288,040	2,160,975	2,160,975	2,160,975	2,160,975	2,160,975	2,160,975	2,160,975	2,160,975	2,160,975	2,160,975
Vegetable - addition of CSA techniques & swapping diesel to small solar irrigation systems		- 156,275	174,930	543,205	758,205	758,205	671,280	671,280	671,280	671,280	671,280	671,280	671,280	671,280	671,280	671,280
Shea Butter - improved agroforestry, incremental benefits			- 272,306	- 310,599	- 76,586	- 53,327	- 28,826	- 18,427	31,692	130,624	283,281	564,321	750,077	750,077	750,077	750,077
Arabic Gum - improved agroforestry, incremental benefits			- 229,758	- 283,325	- 37,860	31,333	212,840	455,152	767,096	1,087,549	1,437,786	1,610,777	1,610,777	1,610,777	1,610,777	1,610,777
Economic Net Income		- 3,308,436	- 6,593,868	- 2,815,409	4,275,805	9,321,566	16,009,236	16,262,109	16,624,172	17,043,758	17,545,451	18,000,482	18,186,238	18,186,238	18,186,238	18,186,238
	IRR	**33%**														
	NPV	**$ 58.6**	**million US$**													