Annex 9 – Economic and Financial Analysis

Contents

Economic and Financial Analysis

A. Introduction

1. The economic and financial analysis of the “Forest Resilience of Armenia, enhancing adaptation and rural green growth via mitigation” project aims to identify the net incremental financial and economic benefits generated by the investment. The project’s objective is to ensure that by 2027 CO2e removals from the forests subsector are increased by at least 11.9 percent via sustainable climate adaptive forestry investments and fuelwood energy efficiency with effective involvement of communities. The core intervention areas include rural communities in the two districts of Syunik and Lori, characterized by high levels of rural poverty and by being home to 47 percent of national forests.

2. Direct beneficiaries of the project include 377,308 Individuals (or 12 percent of the national population) in the districts of Lori and Syunik. Direct beneficiaries include also local institutions such as the Hyantar and relevant municipalities (15 municipalities and 207 rural communities) which will be supported in adopting effective governance and adaptive management of forests including wood and non-wood products, and national institutions such as the Ministry of Nature Protection, the Ministry of Agriculture the ministry of Economy and Innovation, the Ministry of Territorial Administration and Development, and the Ministry of Energy and Natural Resources. An indirect positive impact is expected in terms of increased carbon stocking, reduced emission from rural EE and in terms of market opportunities (EE) for the entire population of Armenia.

3. As detailed in the analysis sections below and summarized in the conclusion of the aggregated economic and financial analyses, the project demonstrates efficiency in the achievement of its mitigation targets. The Financial analysis shows a 20 year IRR equivalent to 13 percent (higher than the financial discount rate used as a relevant cost of capital for private investment decision).[1] Overall, the economic activities related to the project show attractiveness for the private sector and for the households beneficiaries. The project’s efforts on the policy and regulatory framework will reduce the incentives for unsustainable practices (e.g., illegal logging) and will strengthen the economic opportunities related to the forestry and energy sectors (biomass value chain).

4. On the Economic side of the analysis, at aggregate level and accounting for relevant economic and ecosystem benefits (including the valuation of CO2e explained in section D below), the project shows very solid parameters, with a E-IRR (over 100 percent), with USD 272.1m NPV. The project seems solid under the cost and benefit sensitivity analysis and also according to the variation in the valuation of carbon price.

B. Project benefits

5. The project will be implemented via three interconnected components (plus project management):

   1. Climate Change mitigation via climate adaptive silviculture and increased forest cover;
   2. Promoting forest Sustainability reducing forest degradation drivers and adaptation deficit of rural communities;
   3. Strengthening governance of Forest resources and climate change’s impact management at community, as well as local and central government levels.

6. The increased carbon removals generated by the project will depend on forest related investment, under component 1, and on climate adaptive capacity development planned in Component 2 and Component 3. The **benefits in increase carbon storage capacity**, the major ecosystem service generated by the project’s investments will derive from: (a) the increase of forest coverage (+2.5 percent of the current levels); (b) the improved management of about 135,000 ha of existing forests (shifting from 60 percent to 29 percent of forest degradation); (c) improving the energy efficiency of at least 9,000 rural households via tailored investments in heating stoves and fuelwood management practices, materials, trainings and awareness campaigns. In addition, the project will also create economic opportunities associated to the

[1] See section D, key parameters

investment in forestry and energy efficiency. These opportunities represent a market incentive, and contribute to ensuring the sustainability of the project. They include: (i) **local manufacturing of improved stoves** (the project's support will allow breaking the market and technological barriers to the development of a sustainable local demand); (ii) **increasing the private sector's capacity** on climate adaptive silviculture, which in turn will increase the capacity to respond to the possible public procurement of seedlings to meet the national NDC forest-related targets; (iii) **additional ecosystem-services** related activities, such as increased non-wood forest product harvesting and beekeeping opportunities from the improved conditions of forests. Investments in technology transfer and training of local manufacturers will create a domestic supply of EE appliances for rural households sold at a lower price than substitute imported stoves. The involvement of both the private and the public (Ministry of Economy) sectors in generating a market for efficient appliances will guarantee sustainability and scalability of the project investments. Finally, the investment's benefits are also expected to include the generation of additional full-time equivalent jobs in climate adaptive silviculture activities, coppicing activities and local manufacturing of energy efficient stoves.

7. The financial and economic benefits generated by the project are described in the following sections.

C. Structure of the analysis

8. The structure of the analysis follows that of the project, based on models for three main clusters of activities financed by the project:

(a) **Forestry:** improved ecosystem service provision (CO2e sequestration) – resulting from the direct investment under component 1, from the overall improved governance on forests, and from sustainable coppicing supported by the project. The analysis has focused on:
- Afforestation-Reforestation in State Land
- Afforestation-Reforestation in Municipality Land
- Forest Enrichment in State Land
- Benefits from increased availability of non-wood forest products.
- Potential capacity at national level to achieve forestry-related NDC targets

(b) **Energy efficient stoves**: incremental benefits from the use of EE stoves, and from the promotion of stoves manufacturing – resulting from the investment under the second component. For this cluster, the analysis has focused on:
- Adoption of EE stoves: financial and economic benefits
- Manufacturing of EE stoves: financial benefits

(c) **Additional small-scale economic activities**: these include activities related to the improved conditions of forests and ecosystems, triggered by the project's cross-cutting and component 3-specific provisions of capacity development. These focus on:
- Private coppicing activities (including benefits from capacity development)
- Private sector climate adaptive silviculture development (seedling production nurseries)
- Establishment of new beekeeping activities

9. In order to measure the achievement of the project's objective of mobilizing investments to accelerate the adoption of climate adaptive silviculture and afforestation / reforestation / forest enrichment conducive to carbon sequestration, besides creating economic development and employment opportunities, traditional financial models are a useful but not sufficient tool. Besides for the quantification of the potential financial and economic benefits of the project's investment (both, grant GCF resources and co-financing), the models used in the analysis were used to guide the project cost structure and co-financing requirements, the investment-specific concessionality levels, and to identify the possible success factors and complementary required actions.

D. Key Assumptions

10. The parameters for the models are based on information gathered during the project design, including interviews with farmers and entrepreneurs, information from the donor agencies operating in Armenia, market analysis and some design team's estimates. Price information gathered includes in particular costs of labor (skilled and unskilled rural wages), capital costs (equipment, tools), inputs, and transport costs to market. Conservative assumptions were made both for inputs and outputs, taking account possible risks. A list of prices used in the economic and financial analysis is available in the "Prices" spreadsheet of the EFA document.

11. **Models Characteristics.** All models aim to identify incremental costs and revenues related to the introduction of new technologies or practices and associated to the investments. For forestry, the investment are foreseen from year 1 to year 5 (as activities evolve from nursery establishment to tree planting and need additional investment), while for the other activities investment is generally limited to the first year (procurement of equipment, tools, machineries, civil works).

12. **Adoption rate**. Aggregated benefit cash flows are calculated taking into account variable adoption rates, generally between 80 and 90 percent, reflecting the relative scarcity of entrepreneurial skills, adjusted to the models. This allows a conservative representation of the benefits projections.

13. **The impact of climate pattern**. Based on the climate scenario described in described in Section 2 of the Feasibility study, the main climate change related stressors to forestry comprise generalized temperature and water stress recurrence. The consequences of these stressors were taken into account for the selection of the practices proposed by the project on forestry investment, with consequences on the composition of the related costs. In particular, aiming to increase the survival rates up to 75-80 percent from a baseline of less than 70 percent, this included the use of climate adapted tree species and an ideal composition of different species per hectare (in order to increase the resilience of the new forests) and 30 percent replanting of seedlings in the second year after planting. For other models, climate pattern has been taken into account by adjusting the yield / harvest potential to the major climate related stressors. Such climate related stressors are assumed resulting in an average 20 percent decline in incremental benefits once in every 4 years applied to all models. The technologies and practices supported by the project are more suitable to the climate change context and generate higher incremental benefits in the local context, despite their higher costs than BAU practices in the country.

14. **Lending Terms.**[2] When required, essentially for the activities that envisage a contribution from the private sector to the investment costs, the analysis has used the maturity and interest rates prevailing in the Armenian financial sector (this includes both commercial loans with above 1 year duration, and consumer loans with below 12 months duration, with average interest rates between 10 and 15 percent for loans in local currency). All loans are expected to be repaid in equal instalments over a five-year period. The loans were assumed to have a one-year grace period. Interest on the entire amount outstanding would be paid during the grace period.

15. **Discount Rate.** The financial discount rate has been set at 12%, corresponding to the average interest rates for short-medium term loans (relevant to the private businesses and consumption patterns of the context)[3] and their trends in the last years (Source: CBA compendium of interest rates). The social discount rate at 6% reflects the society intention to give value to future benefits (ie, increased ecosystem services) renouncing to part of the current consumption.[4] The discount rate is used as selection criterion to consider viability for the project's investments with an IRR above the opportunity cost of capital.

16. **Analysis period**. All models were analyzed considering two time horizons: 10 years for the financial prospects under market conditions, and 20 years for the capitalization period of the investment incarbon sequestration. More details on the production and financial parameters used in the models are found in the EFA spreadsheet.

17. **Specifically for the economic analysis**, the following assumptions have been considered:

[2] The source for these assumptions is the Central Bank of Armenia. For more details, see the financial sector in Section III of the Feasibility Study.
[3] See section on EE stoves.
[4] Ref: EIB, March 2013. The paper quotes also European Commission recommendation for social discount of 5.5% for Cohesion countries and 3.5% for other EU countries.

- **Shadow exchange rate** (SER), estimated at 1.0 USD = 513 AMD (conversion factor: 1.06).
- **Price conversion factors**,[5] varying between 0.79 and 0.83, with a standard of 0.83 (accounting for VAT, the main tax transfer in the project sphere of intervention).
- **Valuation of ecosystem services.** For **CO2e sequestration potential,** the analysis considered the shadow price of USD 40/tCO2 as the minimum within the range of social value of carbon needed in 2020 to stay consistent with achieving the temperature goal of the Paris Agreement as identified by the High Level Commission on Carbon Prices (World Bank, 2017[6] and 2018[7]). For **other ecosystem services**, only the harvesting of wild fruits and beekeeping activities, have been accounted for in the financial and economic analyses. For the remaining ecosystem services – erosion control, pollination, water flow regulation and habitat provision - no economic values were found in the country. Therefore, they could not be quantified in the ex-ante economic analysis at project design.

E. The analysis

18. **Summary.** A detailed description of the use models is provided within the sections below. While on the financial side, the project shows a solid prospect for entrepreneurial activities and a relatively low outlook for the forestry activities (the latter typically with a public good outcome), the aggregated economic benefits show the effectiveness of the operation (ie, when accounting for the carbon sequestration as main ecosystem benefit quantified in the analysis). More specifically, the main result of the financial analysis suggest: (i) a low financial returns for the forestry investments (i.e., negative NPV for virtually all forestry investment, remaining barely positive for the afforestation in forest land considering a twenty-year period of analysis); (ii) positive financial prospects for entrepreneurial activities such as sustainable coppicing, beekeeping, stove manufacturing, and climate adaptive seedlings production in nurseries; (iii) limited yet positive incremental financial benefits from non-wood forest product harvesting associated to the forestry investment. The negative outlook of forest investments shows how important is the role of public resources in the operation, and suggests that it is to the Government to take over, as a fiscal compromise in exchange for the future ecosystem services produced by the investment.

E.1 Forestry investment

19. The proposed investments aim at ensuring carbon sequestration by effective afforestation, reforestation and forest enrichment on degraded forest areas. Ecosystem services play an important role in the estimation of the net incremental benefits. The valuation of the incremental carbon sequestration is taken into account in the economic analysis only, while the incremental financial benefits from the increasing non-wood forest product harvest are analyses separately (accounted as a separate entrepreneurial activity associated to the increased coverage and improved conditions of the forests).

20. Three forest models have been designed according to the project requirements and are based on different conditions on the ground during the design (See section IX of the Feasibility Study – detailed programme description), which give a survival rate of 80 percent – compared to the average 60 percent under BAU. Key differences between the three models are the seedling density, and the need or not for fencing to protect from animal intrusion during the forest growth. Common the mixed composition of tree species and the proportion between species, representing the best mix to respond to the changing climate conditions and pattern and to enhance the resilience of forests by diversifying its composition (see table 1, below). Common to the three is also the public procurement of seedlings from public nurseries that are jointly supported by the project and by the Government of Armenia (in this way, the project will also support the country capacity to produce seedlings and satisfy its future demand). All investment will be carried out under the supervision of Hyantar, in collaboration with other local institutions, and with the participation of

[5] Details on prices and their conversion factors are presented in the respective spreadsheets of the EFA.
[6] World Bank, 2017. Guidance note on shadow price of carbon in economic analysis.
[7] World Bank, 2018. State and Trends of Carbon Pricing.

locally recruited labour.[8] Tables 1 and 2 describe the benefits structure of the three models, while the three models' particularities are described as follows:

a. Afforestation / reforestation in State Owned land. The investment is made for a **2,000 seedling per ha** density (the highest among the three models), and requires fencing off over 80 percent of the selected land. 30 percent of the seedlings planted on the first year are replanted in the second year. The target coverage for this investment is **2,350 ha** in total.

b. Afforestation / reforestation in Municipal land. With a **1,000 seedling per ha** density, also required investing fencing off of 80 percent of the selected land. The total target coverage is **1,000 ha**.

c. Forest enrichment in State Owned land. The estimated plantation density is **600 seedlings per ha** due to the specific conditions of the target area for the investment, which is partly covered by degraded forest and thus needs for less investment intensity for restoration. For this area, fencing is not required as it would not be cost-effective. The total target coverage is **2,350 ha**.

21. In order to achieve the target of 5,700 ha, the project will first have to ensure that the capacities to produce seedlings are met, then will be able to mobilize (under E-PIU management) the required seedlings. Considering the current seedling capacity and how rapidly the existing nurseries can be rehabilitated or improved, the project will distribute the forestry activities as follows: 10 percent of the 5,700 ha in Year 2; 25 percent in Year 3; 30 percent in year 4 and 5; and the remaining 5 percent in year 6 (for further details, the organization of forestry investment is reported in the EFA spreadsheets).

Table 1. Composition of tree species for the three types of investment (and seedling density)

Tree species	%	a. Total seedlings / ha	b. Total seedlings / ha	c. Total seedlings / ha
Pine (Pinus)	14%	280	140	84
Oak (Quercus)	21%	420	210	126
Hornbeam (Carpinus)	14%	280	140	84
Ash (Fraxinus)	21%	420	210	126
Wild fruit tree / berries	30%	600	300	180
	100%	2,000	1,000	600

Table 2. Benefit assumptions of the selected tree species

Benefit Assumptions	Unit	Pine (Pinus)	Oak (Quercus)	Hornbeam (Carpinus)	Ash (Fraxinus)	Mixed wild fruit trees
Survival rate	%	80%	80%	80%	80%	80%
Number of trees	tree/ha	224	336	224	336	480
1st thinnig	year	20	20	20	20	20
2nd thinnig	year	50	50	50	50	50
Sanitary cut quantity at 10th year	m3 / ha	N/A				
Sanitary cut quantity at 20th year	m3 / ha	1.12	1.68	1.12	1.68	2.40
Harvesting of commercial timber	year	70	70	70	70	70

22. Mixed wild fruit trees include a wide variety of fruit trees and berries.[9] The ones accounted for financial and economic benefits include sea buckthorn, wild pears, wild apples, and wild plums. Under the three types of investment described above, these wild fruits are expected to generate limited yet positive income opportunities (Table 3).

Table 3. **Expected harvest from wild fruits trees**

	Unit	Y1-Y5	Y6-Y10	Y11-Y15	Y16-Y20
a. Afforestation / reforestation in State Owned land					
Sea buckthorn	kg/ha	0	135	195	195

[8] The project will need to mobilize about 140,000 person days, equivalent to over 60 full time skilled workers, and about 570 unskilled workers.
[9] Details are provided in the section 'Project area and target group" of the feasibility study

	Unit	Y1-Y5	Y6-Y10	Y11-Y15	Y16-Y20
Pear	kg/ha	0	210	420	420
Apple	kg/ha	0	210	420	420
Plum	kg/ha	0	210	420	420
a. Afforestation / reforestation in Municipal land					
Sea buckthorn	kg/ha	0	135	195	195
Pear	kg/ha	0	210	420	420
Apple	kg/ha	0	210	420	420
Plum	kg/ha	0	210	420	420
a. Forest enrichment in State Owned land					
Sea buckthorn	kg/ha	0	135	195	195
Pear	kg/ha	0	210	420	420
Apple	kg/ha	0	210	420	420
Plum	kg/ha	0	210	420	420

23. **Financial analysis**. The financial parameters of the investment consider the cost-sharing between GCF grant (fencing-off of planted areas and of 90 percent of labour costs) and the Government contribution (seedlings, transport and 10 percent of the labour cost, including maintenance and surveillance). Table 4 provides an overview of the key financial parameters in the base scenario, taking into account that financial benefits within the 20 years time horizon are limited to some wild fruit harvesting and sanitary cuts on year 20 (almost uninfluential in determining the financial performance of the investment).

24. In the model, the impact of inter-year climate variability, exacerbated by the climate change scenario, has been computed into the estimations. The models considered a decreasing trend in the benefit stream within the 20 years horizon and inter-year variations from the average (i.e., a 20 percent drop of benefits every 4 to 5 years and sporadic increases of benefits).

25. A **sensitivity analysis for extreme climate related events** beyond prediction was also carried out (such as frosts, or natural hazards that generate unexpected increase of costs of seedlings or reduced benefits due to a lower survival rates of trees). While the models show very high financial sensitivity to shocks caused by extreme climate related events, different is the situation when considering economic benefits, which presents a positive outlook even in case of 30 percent drop of benefits (described later, in the dedicated paragraphs – and detailed in Table 6).

Table 4. Financial costs and performance under base scenario

	1-ha Unit Model		Whole investment under the Project				10 Years horizon		20 Years horizon	
	Total Inv. (USD)	GCF inv. (USD)	Unit	Quantity	Total Inv. (USD)	GCF inv. (USD)	IRR	NPV (USD)	IRR	NPV (USD)
A/R in State Land	1,141	729	ha	2,350	2,638,618	1,684,564	<0	(1,349,999)	8%	(479,494)
A/R in Municip. L.	755	537	ha	1,000	754,948	537,328	<0	(391,181)	5%	(205,967)
Forest Enrichment	614	474	ha	2,350	1,443,135	1,115,028	<0	(800,229)	2%	(539,078)

26. The financial performance of the forestry investment is overall very low, and with limited attractiveness for private sector's contribution. However, there are various sets of positive benefits. First, there are considerable gains in reforestation, such as the protection of downstream agricultural land and cities from floods and water scarcity, and reduced risk of natural hazards. These benefits are not quantified in this analysis, but they represent tangible benefits and a significant incentive for the economy. Second, more quantifiable benefits include the increased income opportunities from NTFP harvesting (envisaged after the first five year of investment). However, in all cases the financial profitability is very limited (almost always negative under both the 10- and 20-year scenarios, except an almost positive result under the highest density investment / 20-year).

27. Such results do not suggest possible involvement or interest of the private sector. On the contrary, expectedly the low level of private / financial profitability suggests therefore that public resources are

required for forestry investment (as the benefits will largely be only of economic nature). These results justify also the current cost sharing set up, with about 70 percent of the investment under GCF to unlock the seedling production capacity and to ensure the transfer of knowledge on climate adaptive silviculture. Without GCF grant such investment would not be affordable for public resources only, also as their current seedling production capacity is limited to less than 10 percent of the potential capacity after project intervention. However, the support provided by the project to increased the seedling production capacity will ensure a feasible exit strategy and sustainability of the overall investment.

28. **Labour**. The forestry investment are highly depending on labour. The project's assumption and one of the key success factors is to consider labour for forestry as a resource (and potential investment). Throughout the investment phase, local labour will be contracted and will be trained upfront and on the job, ultimately increasing local capacities to manage forest and enhancing the sustainability of the forest investment. In order to cover the targeted 5,700 ha, the project will need to mobilize almost 140,000 working days, which correspond to about 630 full time equivalent jobs (over 60 skilled workers, and about 570 unskilled).

29. **Economic analysis**. Economic benefits associated with forest investment are essentially composed of the valuation of carbon sequestration. The analysis has taken into account the valuation of the incremental carbon sequestration generated by the investment, at the set value of 40 USD / tCO2e, and taking into account the sole above and below ground incremental biomass associated by the forest regeneration / afforestation. It is important to notice that the analysis is conservative as it does not estimate results of other associated sources of carbon sequestration (e.g., carbon in soils). Table 5 summarizes the expected value for each tree species under each type of investment.

30. **Table 5. Expected tCO2e sequestration from tree species under different forestry investment**

	Unit	Y1-Y5	Y6-Y10	Y11-Y15	Y16-Y20
a. Afforestation / reforestation in State Owned land					
Pinus	tCO2e/ha	0.11	0.20	0.39	0.27
Quercus	tCO2e/ha	0.10	0.38	0.87	1.18
Carpinus	tCO2e/ha	0.09	0.31	0.46	0.61
Fraxinus	tCO2e/ha	0.10	0.36	0.54	0.71
Wild Fruits	tCO2e/ha	0.15	0.60	1.20	1.65
a. Afforestation / reforestation in Municipal land					
Pinus	tCO2e/ha	0.05	0.19	0.43	0.59
Quercus	tCO2e/ha	0.04	0.16	0.23	0.31
Carpinus	tCO2e/ha	0.05	0.18	0.27	0.35
Fraxinus	tCO2e/ha	0.08	0.30	0.60	0.83
Wild Fruits	tCO2e/ha	1.00	1.10	1.00	0.80
a. Forest enrichment in State Owned land					
Pinus	tCO2e/ha	0.03	0.06	0.12	0.08
Quercus	tCO2e/ha	0.03	0.12	0.26	0.35
Carpinus	tCO2e/ha	0.03	0.09	0.14	0.18
Fraxinus	tCO2e/ha	0.03	0.11	0.16	0.21
Wild Fruits	tCO2e/ha	0.05	0.18	0.36	0.50

31. Overall, the **economic returns** of the forestry interventions are largely positive. All three types of investment generate positive economic IRR and NPV under the base scenario (which incorporates already the expected **impact of climate change**) under the 20-year horizon (the analysis shows that as expected a 10-year economic scenario for forestry is not enough to generate the sufficient economic returns). Table 6 provides an overview of the results.

32. The **sensitivity analysis** has taken into account two main variables:

- A significant **drop in the value of tCO2e**: even when considering a lower valuation of CO2e (at 10 USD or 5 USD per ton, the investment show positive results (IRR are estimated at 10 percent for the A/R in forest land, and 7 percent in Municipal land for 10 USD / tCO2e, and 9 and 6 percent for 5 USD / t CO2e). Forest enrichment remains an exception, showing economic-IRR below the 6 percent threshold discount rate.

- A **decrease in benefits or equivalent increases in costs of inputs**: overall the analysis shows positive results, with a sole exception for forest enrichment.
- In conclusion, the investment is largely robust under the economic point of view. Forest enrichment is the less attractive amongst the three models, but it is nevertheless a feasible and important public investment as: (i) it is the only technically viable option in certain cases, and (ii) the assumptions under sensitivity (especially on carbon value) are very conservative.

Table 6. Economic benefits from all forest investments including sensitivity analysis

	A/R in State land (2,350 ha)				
ECONOMIC BENEFITS	Detailed Results	10 year results		20 year results	
		IRR	NPV	IRR	NPV
Base scenario		-15%	(1,000,639)	15%	1,769,525
Sensitivity Analysis	10USD/tCO2e	-24%	(1,269,796)	10%	642,479
	5USD/tCO2e	-25%	(1,308,642)	9%	492,269
	Costs: +10%	-18%	(1,170,319)	13%	1,599,845
	Costs: +20%	-19%	(1,340,000)	12%	1,430,165
	Costs: +30%	-21%	(1,509,680)	11%	1,260,484
	Benefits: -10%	-18%	(1,063,927)	13%	1,454,405
	Benefits: -20%	-19%	(1,116,666)	12%	1,191,804
	Benefits: -30%	-21%	(1,161,292)	11%	969,603

	A/R in Forest land (1,000 ha)				
ECONOMIC BENEFITS	Detailed Results	10 year results		20 year results	
		IRR	NPV	IRR	NPV
Base scenario	Base scenario	-24%	(333,360)	10%	215,673
Sensitivity Analysis	10USD/tCO2e	<-30%	(382,951)	7%	23,916
	5USD/tCO2e	<0	(391,217)	6%	(8,044)
	Costs: +10%	-26%	(380,740)	9%	168,292
	Costs: +20%	<-30%	(428,121)	8%	120,912
	Costs: +30%	<-30%	(475,501)	7%	73,531
	Benefits: -10%	-26%	(346,127)	9%	152,993
	Benefits: -20%	<-30%	(356,767)	8%	100,760
	Benefits: -30%	<-30%	(365,770)	7%	56,563

	Forest Enrichment in State land (2,350 ha)				
ECONOMIC BENEFITS	Detailed Results	10 year results		20 year results	
		IRR	NPV	IRR	NPV
Base scenario	Base scenario	<-30%	(720,126)	7%	54,010
Sensitivity Analysis	10USD/tCO2e	<-30%	(790,050)	3%	(216,368)
	5USD/tCO2e	<-30%	(801,704)	3%	(261,430)
	Costs: +10%	<-30%	(811,941)	6%	(37,805)
	Costs: +20%	<-30%	(903,756)	5%	(129,621)
	Costs: +30%	<-30%	(995,572)	4%	(221,436)
	Benefits: -10%	<-30%	(738,128)	6%	(34,369)
	Benefits: -20%	<-30%	(753,130)	5%	(108,017)
	Benefits: -30%	<-30%	(765,824)	4%	(170,335)

33. **Additional considerations**. The project aligns with the **NDC (2015) target to** increase Armenia's forest cover from about 11.8 percent to 20.1 percent by 2050. This corresponds to an increase of the forest coverage of about 300,000 ha. The project will increase the seedling production capacity up to a maximum of 2.4 million seedlings per year, which correspond to about 1,600 ha / year. When considering the whole period after the project completion 2027-2050, this corresponds to about 36,000 ha or 12 percent of the NDC target by 2050. Table 7 below shows that when considering only the seedling production capacity of Hyantar, the NDC target would require an investment for 24 additional nurseries with annual production capacity of 0.6m seedlings. Covering the gap left by the project in establishing the required climate adaptive

silviculture capacity would cost to the Government at least 4 additional m USD, plus the costs of operating 24 additional nurseries.

Table 7. Seedling requirement to meet NDC forestry targets by 2050.

		2027-2030	2031-2040	2041-2050		
Targets NDC	Ha / period	33,441	111,470	111,470		
Seedlings Availability (with Project)	Million Seedlings	7.2	24.0	24.0		
Potential coverage of increased production capacity	ha	4,800	16,000	16,000	**TOTAL =** 36,800 ha	12%**of NDC target**
Seedlings Gap:	Million Seedlings	43.0	143.2	143.2		
Gap: needed investment to ensure fulfilling the requirement for NDC forest targets:				→	**Related investment (civil works only):**	
Number of nurseries with annual capacity of 600,000 seedlings:		24	24	24	→	**USD 4,008,000**

E.2 Energy efficient stoves: use and manufacturing

34. **Investment in reduction of energy requirements** via increased use and availability of improved EE wood stoves (Comp2) represent an essential element to ensure the sustainability of the physical investment in forestry, and represents less than one fourth of the total budget (23 percent). Despite the prevailingly low levels of income in the target rural areas, and the relatively high incremental cost of the improved technology (on average, 350 USD / stove, corresponding to over a third of the average annual income of a rural HH), the private sector's contribution to the investment in EE stoves component is still set at about 15 percent. Within the same framework, the project's investment in developing local EE stoves manufacturing capacities which will allow to break a technological barrier by allowing the private sector to invest (including via commercial loans) and meet the increased demand for EE stoves.

35. The access to financial products is a precondition for the sustainability of the investment under component 2. In this respect, the fluidity of the financial sector in the country represents a significant asset. The banking sector and credit organization provide financial services to a large share of the population (over half of the adults borrowed in 2017). While the agricultural sector represents only about 5 percent of the total portfolio (steadily growing in the last years), the overall access to credit is quite high (the share of adults borrowing to start a farm or business passed from 9 to 17 percent between 2014 and 2017), with manufacturing and trade representing over a third of it (CBA)[10]. Despite a relatively high cost of loans (interest rates at about 15 percent in local currency), the financial system is sufficiently developed to provide the required liquidity to establish new investment and enterprises in the EE sector.

36. **EE stoves**. Supporting the adoption of improved EE stoves will generate at least 30 percent reduction in fuelwood consumption compared to BAU (from 8m^3 to 5.4m^3/year),[11] corresponding to savings for up to one third of the annual income of a rural household (115 USD per month). Currently, improved EE stoves are not marketed nor produced in Armenia. In order to break the current lack of technology and to ensure the generation of the demand for improved EE stoves, the project has identified a twofold approach:

(i) **by importing of highly energy efficient stoves (absent from the local market),** for demonstration. The efficiency ranges from 60-70 percent efficiency, with costs comprised between 400-600 USD each. Considering the lack of alternatives and the high cost as share of rural HH income, the project set the concessionality between 50-60 percent. Such level (corresponding to an investment for the project between 200 and 350 USD, and for the beneficiaries between 200 and 250 USD), would allow the beneficiaries to **enjoy net savings from reduced fuelwood consumption already from the second year after the investment. These net savings represent the needed adoption**

[10] https://www.cba.am/en/sitepages/statmonetaryfinancial.aspx
[11] http://www.nature-ic.am/Content/announcements/6952/UNDP-RECS-Report-ENG_01.13.15.pdf

incentive for the target beneficiaries in rural areas, and represent the opportunity to increase their use beyond the project intervention by generating awareness, trust and breaking the market barrier. As a result, the technology can start being adopted, serving as example and driver for a demand of technology shift;

(ii) by supporting the local manufacturing of more affordable improved stoves (min 52 percent efficiency, for about 250 USD), the project will ensure sustainability of the technology transfer. For this model, the project has set the concessionality at 20 percent, as with an investment of 50 USD, even the beneficiaries with lowest purchasing power would appreciate the incentive to investment in the new technology, and pay back the investment within one year. With the energy efficiency trainings, the awareness and information campaigns, and the support for the adoption, the project will create a demand for stoves beyond the project area. The local manufacturing of stoves is a potentially lucrative economic activity (the 10-year IRR and NPV are positive even with a reduction of sale price of one stove by 15 percent), and can moderately contribute to employment generation in rural areas (especially for the youth in rural areas).

37. **From the Households' perspective**. Three models of stove have been taken into account. The selection is based on market and social analysis, aiming to identify niches or market failures that the project would be able to address. The first two models are imported, and have relatively high energy efficiency standards. The third model is the locally manufactured one (based on the experience in the region)[12], with slightly lower efficiency, but also cheaper.

a. Imported EE stoves (60 percent EE) – 400 USD cost – 50 percent efficiency gain compared to BAU (existing stoves with less than 40 percent EE) – 15 years duration. As the domestic production of EE stoves does not exist in the country, the project will initially support the adoption of imported stoves. The models available in Armenia in urban contexts have different levels of efficiency and prices. EE stoves with 60 percent efficiency cost about 400 USD, and generate annual savings in fuelwood for about 129 USD (Payback 3.1 years). Yet the initial investment is quite high, and even contracting a consumption loan (1 year) the household's financial effort on the first year is 296 USD (equivalent to 2.7 month income). Especially in a rural context, with limited livelihoods and absence of knowledge of the potential of such technology, the technology would not be adopted in absence of the project's support. The support in this case is set at USD 200 (50 percent concessionality), which is **the required incentive to ensure that the trust and market barriers are broken and the technology can start being adopted**, serving as example and driver for a demand of technology shift.

Fuelwood cost Baseline per Household (AMD):		
Average consumption of fuelwood	m3/y	8
Corresponding CO2e emissions per HH	tCO2e	5.4
AMD / month	AMD/m	31000
AMD / year (4 m/y)	AMD/y	124000
Annual cost	**USD/y**	**257**
Imported more efficient EE stoves (60% EE)	**USD**	**400.00**
Efficiency gain	%	50%
Expected savings in fuelwood consumption	m3/y	4.0
Expected consumption of fuelwood	m3/y	4.0
Expected emissions per HH	tCO2e	2.7
Expected emission reduction per HH	tCO2e	2.7
Financial benefits (Individual HH):		
Annual fuelwood requirements	**USD/y**	**129**
Annual Savings on fuelwood	USD/y	128
Payback period (years)	years	3.1
EE stove cost with GCF support	USD	200
Payback period with GCF support	years	1.6
Ecosystem benefits:		
Fuelwood requirements (all beneficiaries)	m3/y	36,000
Fuelwood saved (all beneficiaries)	m3/y	36,000
Expected emissions (all beneficiaries)	tCO2e	24,300
Expected emission reduction (all beneficiaries)	tCO2e	24,300

The financial benefits of the investment are represented by the financial savings in fuelwood cost, while for the economic benefits the saved amount of fuelwood has been taken into account, valuing its equivalent reduction of CO2e emissions (5.6 tCO2e/HH/year in BAU, and 3.8 tCO2e/HH/year with this stove – see table).

The analysis has considered two scenarios (Table 8.a and 8.b): (a) in absence of a GCF grant; and (b) with a GCF contribution. While results are positive in both scenarios, the high investment cost upfront required by the rural households (even with the support of a loan) would make the investment feasible, but not attractive considering the scarce financial availability of the target beneficiaries. The limit to make the investment financially viable is with an increase in cost of maximum +60 percent.

[12] Among others, USAID in Georgia: http://weg.ge/sites/default/files/wood_heating_stoves_en.pdf

Table 8.a Financial and economic performance of imported 60% EE stoves – without GCF Grant

60% EE stoves	Financial	10 years	20 years	Economic	10 years	20 years
Base scenario	F-IRR	44%	46%	E-IRR	140%	140%
	F-NPV	$551	$926	E-NPV	$1,345	$2,165
Sensitivity analysis						
Costs+10%		10 years	20 years		10 years	20 years
	F-IRR	37%	39%	E-IRR	122%	123%
	F-NPV	$454	$778	E-NPV	$1,249	$2,017
Costs+65%		10 years	20 years		10 years	20 years
	F-IRR	1%	4%	E-IRR	58%	59%
	F-NPV	($76)	($34)	E-NPV	$719	$1,204

Table 8.b Financial and economic performance of imported 60% EE stoves – with GCF Grant

60% EE stoves	Financial	10 years	20 years	Economic	10 years	20 years
Base scenario	F-IRR	168%	168%	E-IRR	140%	140%
	F-NPV	$739	$1,115	E-NPV	$1,345	$2,165
Sensitivity analysis						
Costs+10%		10 years	20 years		10 years	20 years
	F-IRR	128%	128%	E-IRR	<high>	<high>
	F-NPV	$643	$967	E-NPV	$1,438	$2,206
Costs+65%		10 years	20 years		10 years	20 years
	F-IRR	21%	23%	E-IRR	289%	289%
	F-NPV	$113	$154	E-NPV	$908	$1,393

Table 8.c Economic performance of imported 60% EE stoves with different Carbon Pricing

60% EE stoves	10 USD / t CO2e	10 years	20 years	5 USD / t CO2e	10 years	20 years
Base scenario	E-IRR	84%	84%	E-IRR	71%	72%
	E-NPV	$812	$1,326	E-NPV	$713	$1,172

b. Imported EE stoves (70% EE) – 600 USD cost – 75 percent efficiency gain compared to BAU (existing stoves) – 15 years duration. These are the most expensive ones considered in the analysis. Their design is suitable to the local rural context and their efficiency allows to save up to 190 USD/ season (compared to an actual average expenditure in fuelwood for heating of about 257 USD / season). Considering the substantially higher savings in fuelwood consumption (194 USD per year) and subsequently in carbon emission reduction (25 percent of BAU), the project will consider importing them. From the rural household's perspective, such cost is prohibitive, even with a consumption loan, as the net disbursement on the first year would be about 443 USD (equivalent to almost 4 months income). Only a short-term 3-year loan (not applicable to consumption) would make the investment feasible for the rural HH (a negative cash flow of 25 USD for two years, before generating net savings). Considering how the market and financial products would not be suitable to ensure the adoption of such technology even when generating such a high net savings, for these stoves the project has set the grant to 350 USD (60 percent concessionality). This level

Imported EE stoves (70% EE)	USD	600.00
Efficiency gain	%	75%
Expected savings in fuelwood consumption	m3/y	6.0
Expected consumption of fuelwood	m3/y	2.0
Expected emissions per HH	tCO2e	1.4
Expected emission reduction per HH	tCO2e	4.1
Financial benefits (Individual HH):		
Annual fuelwood requirements	**USD/y**	**64**
Annual Savings on fuelwood	USD/y	193
Payback period (years)	years	3.1
EE stove cost with GCF support	USD	250
Payback period with GCF support	years	1.3
Ecosystem benefits:		
Fuelwood requirements (all beneficiaries)	m3/y	18,000
Fuelwood saved (all beneficiaries)	m3/y	54,000
Expected emissions (all beneficiaries)	tCO2e	12,150
Expected emission reduction (all beneficiaries)	tCO2e	36,450

corresponds to the minimum to ensure attractiveness for the households, yet maintaining the potential outreach of 9,000 households and significant reduction of CO2e emissions.

Even in this case the analysis has considered two scenarios (Table 9.a and 9.b), depending on GCF contribution. While results are positive in both scenarios, the high investment cost upfront required by the rural households (even with the support of a loan) would make the investment feasible, but not attractive considering the scarce financial availability of the target beneficiaries.

Table 9.a Financial and economic performance of imported 70% EE stoves – without GCF Grant

70% EE stoves	Financial	10 years	20 years	Economic	10 years	20 years
Base scenario	**F-IRR**	45%	47%	**E-IRR**	144%	144%
	F-NPV	$847	$1,398	**E-NPV**	$2,040	$3,256
Sensitivity analysis						
Costs+10%		10 years	20 years		10 years	20 years
	F-IRR	43%	44%	**E-IRR**	137%	137%
	F-NPV	$800	$1,325	**E-NPV**	$1,992	$3,183
Costs+65%		10 years	20 years		10 years	20 years
	F-IRR	30%	32%	**E-IRR**	108%	108%
	F-NPV	$537	$922	**E-NPV**	$1,729	$2,780

Table 9.b Financial and economic performance of imported 70% EE stoves – with GCF Grant

70% EE stoves	Financial	10 years	20 years	Economic	10 years	20 years
Base scenario	**F-IRR**	331%	331%	**E-IRR**	144%	144%
	F-NPV	$1,178	$1,729	**E-NPV**	$2,040	$3,256
Sensitivity analysis						
Costs+10%		10 years	20 years		10 years	20 years
	F-IRR	287%	287%	**E-IRR**	<high>	<high>
	F-NPV	$1,130	$1,655	**E-NPV**	$2,322	$3,513
Costs+65%		10 years	20 years		10 years	20 years
	F-IRR	148%	148%	**E-IRR**	<high>	<high>
	F-NPV	$867	$1,252	**E-NPV**	$2,059	$3,110

Table 9.c Economic performance of imported 60% EE stoves with different Carbon Pricing

60% EE stoves	10 USD / t CO2e	10 years	20 years	5 USD / t CO2e	10 years	20 years
Base scenario	**E-IRR**	86%	87%	**E-IRR**	73%	74%
	E-NPV	$1,240	$1,999	**E-NPV**	$1,091	$1,767

c. Locally manufactured EE stoves (52% EE) – 250 USD cost – 30 percent efficiency gain compared to BAU – 10 years duration (lower than the imported models). The efficiency gains generated by the improved EE locally manufactured stoves allow saving about 77 USD/year in fuelwood (payback of 3.2 years). However, the initial investment represent about 1/5 of the annual income. For the household, the expenses including investment and fuelwood would correspond to about 30 percent of the annual income. While under market conditions this would be prohibitive to the rural poor households living close to forests, **consumption loans represent an actual opportunity**: with a 1-year consumer

Imported more efficient EE stoves (60% EE)	**USD**	**400.00**
Efficiency gain	%	50%
Expected savings in fuelwood consumption	m3/y	4.0
Expected consumption of fuelwood	m3/y	4.0
Expected emissions per HH	tCO2e	2.7
Expected emission reduction per HH	tCO2e	2.7
Financial benefits (Individual HH):		
Annual fuelwood requirements	**USD/y**	**129**
Annual Savings on fuelwood	USD/y	128
Payback period (years)	years	3.1
EE stove cost with GCF support	USD	200
Payback period with GCF support	years	1.6
Ecosystem benefits:		
Fuelwood requirements (all beneficiaries)	m3/y	36,000
Fuelwood saved (all beneficiaries)	m3/y	36,000
Expected emissions (all beneficiaries)	tCO2e	24,300
Expected emission reduction (all beneficiaries)	tCO2e	24,300

loan the investment is substantially affordable, with moderate savings starting from the second year. As such, **the project subsidy for this model has been set at USD 50 (20 percent concessionality)**, which allows the most vulnerable HHs to break the financial barrier, and serves as incentive to stimulate the demand via awareness increase. The critical advantage of this option – making it worth investing GCF grant resources, is the capacity to **create a local market with a limited concessionality**, benefiting from an actual opportunity to (i) **respond to a climate related need of the country**, which is the reduction of unsustainable fuelwood consumption; (ii) **provide the market with a new product**, affordable even in rural areas (even though coupled with a loan) and (iii) **create employment and business** in the biomass value chain and with a new enhanced technology. Importing at first the technologies would be a necessary step for this technological shift. Tables 15I.a and 15I.b summarize the financial and economic benefits of the operation.

The financial benefits are substantially positive, except for the 10 years duration scenario as the 10th year is when the investment is replaced. However, even in this case the model is quite solid, and the wide support from the project to the manufacturers will ensure price competition thus reducing the risk of too high increase of costs.

Table 10.a Financial and economic performance of local 52% EE stoves – without GCF Grant

52% EE stoves	Financial	10 years	20 years	Economic	10 years	20 years
Base scenario	F-IRR	36%	39%	E-IRR	123%	123%
	F-NPV	$171	$433	E-NPV	$648	$1,176
Sensitivity analysis						
Costs+10%		10 years	20 years		10 years	20 years
	F-IRR	15%	24%	E-IRR	91%	92%
	F-NPV	$37	$227	E-NPV	$514	$970
Costs+20%		10 years	20 years		10 years	20 years
	F-IRR	#NUM!	8%	E-IRR	67%	68%
	F-NPV	($98)	$20	E-NPV	$379	$764

Table 10.b Financial and economic performance of local 52% EE stoves – with GCF Grant

52% EE stoves	Financial	10 years	20 years	Economic	10 years	20 years
Base scenario	F-IRR	55%	56%	E-IRR	123%	123%
	F-NPV	$219	$480	E-NPV	$648	$1,176
Sensitivity analysis						
Costs+10%		10 years	20 years		10 years	20 years
	F-IRR	30%	35%	E-IRR	150%	150%
	F-NPV	$84	$274	E-NPV	$561	$1,017
Costs+20%		10 years	20 years		10 years	20 years
	F-IRR	#NUM!	15%	E-IRR	102%	103%
	F-NPV	($50)	$68	E-NPV	$427	$811

Table 10.c Economic performance of imported 60% EE stoves with different Carbon Pricing

60% EE stoves	10 USD / t CO2e	10 years	20 years	5 USD / t CO2e	10 years	20 years
Base scenario	E-IRR	74%	75%	E-IRR	62%	63%
	E-NPV	$330	$658	E-NPV	$270	$565

38. **Support to local manufacturing of energy efficient stoves**. The Project will support technology transfer to ensure that the energy efficient stoves are produced and meet the energy efficiency and safety

requirements. For the analysis, a model for the production of a simple energy efficient stove with an efficiency of about 55 percent was analyzed. The workshop can be established with a relatively limited investment of 22,000 USD (composed of iron modelling tools, welding machines, assembling tools, safety equipment and ventilation, civil works for the refurbishment and adjustment of the workshop and vehicle for transportation), and can have a production capacity of 25-30 stoves / month at full capacity, sold locally at the price of about 200-250 USD / stove. For the operation, the workshop employs one master blacksmith and one apprentice. Additional costs include training and certification. Under these assumptions, the operation is solidly financially viable even with the conservative assumption of a long run success rate of about 80% (or an equivalent unsold of 20%). A 5 years loan can make the investment more attractive as it reduces the initial financial contribution. A sensitivity analysis conducted on the model suggests that the operation is financially feasible even with a drop in the price of stoves by 22 percent (195 USD). Table 11 summarizes the financial performance. The economic benefits consist of savings of fuelwood consumption and related carbon emission reduction as assessed in the section of the technology grant transfers for energy efficient stoves. Appropriate technical assistance, coaching and certifications will be required to ensure that the stove respond to the minimum standards and can contribute to carbon emission reduction.

Table 11. Financial performance of stove manufacturing.

Base scenario:	**IRR**	39%
	NPV	$35,643
Reduction of price by 15%	**IRR**	21%
(212 USD / stove)	**NPV**	$11,752
Reduction of price by 22%	**IRR**	13%
(195 USD / stove)	**NPV**	$603

E3. Additional small-scale economic activities

39. **Private sustainable coppicing activities**. Due to the importance of fuelwood use in the rural areas, promotion of sustainable coppicing practices is a critical activity for the project's theory of change. The project will establish ten demonstration centres, with training of trainers and cascade training to the rural communities. For a period of four years the project will train an average of 32 individuals per season (for four years) and per demonstration site among **rural dwellers are interested in starting a sustainable coppicing business**. The outreach of the demonstration would sum up to about 1,280 individuals who could then replicate the sustainable coppicing practices in at least 1,600 ha. The fuelwood harvested through such incremental sustainable coppicing will substitute in the market the unsustainably logged fuelwood, ultimately determining an increase in carbon sequestration (avoided deforestation).

40. **Financial analysis**. While sustainable coppicing is critical in rural areas, its performance is highly dependent on the price of fuelwood. A private sustainable coppicing business envisages a limited investment of about 1,700 USD, including the required tools. Labour requirements are estimated at 12 person/day per ha (between 5 and 6 cubic meters of fuelwood marketed per person), considering the conditions of Armenian forests (high slopes, and remote forests). With a financial price of wood of about 22 USD (the wholesale price practiced by Hyantar, which is a conservative representation of the market price) the activity is solidly financially viable, with a NPV of 1,050 USD over 10 years (and about 1,350 for the 20-year horizon). The benefit stream under all scenarios (base scenario and the ones for the sensitivity analysis) include all the effect of climate on the actual availability of fuelwood, either reduced by hazards, or by increased logging). Under the alternative scenarios with reduced benefits or increased costs, the 10 years horizon is no longer sufficient. Nevertheless, the private owner could either increased the coppiced surface into remoter areas, or rent the equipment, which has a high value. An important observation on the sustainable coppicing practices is that, in the BAU, it would compete with unsustainable illegal logging. The underlying assumption to the success of the uptake of sustainable coppicing practices is that it represents a legal activity in a context where the enforcement is much more effective (i.e., with project-related work on sustainable forestry and energy practices). Sustainable coppicing practices would be taken up in a context where the project has largely already improved the enabling environment, not only under the point of view of policies and regulatory framework, but also in the overall biomass value chain.

41. **Economic analysis**. The main positive externality of the sustainable coppicing is the potential substitution of use of unsustainably harvested fuelwood. In turn, this may correspond to the improvement of forest conditions (for details, refer to the carbon accounting) passing from 60 percent to 29 percent degradation. Such improvement can be associated with an increase in carbon storage of an average 4.43 tCOe per ha per year. As the sustainable coppicing demonstration will reach out at least 1,600 ha, the overall economic benefit for this activity is the valuation of the corresponding area of improved forest. With a valuation at 40 US$ per ton, the economic benefits of sustainable coppicing show high values (IRR 65 percent and NPV 2,650 USD on 10 years, and 4,070 USD for the 20 years horizon). As such, sustainable coppicing deserves public attention and appropriate incentives, giving sustainable coppicing a critical role in the improved efficiency of biomass value chain. For details, refer to Coppicing spreadsheet in the EFA annex, and a summary is provided in Table 12.

Table 12. Financial and economic performance of sustainable coppicing for private entrepreneurs.

	Financial				Economic			
	10 year results		20 year results		10 year results		20 year results	
	IRR	NPV	IRR	NPV	IRR	NPV	IRR	NPV
Base scenario	35%	1,062	35%	$1,349	65%	2,688	65%	$4,070
Costs: +10%	16%	$205	15%	$219	37%	$1,702	37%	$2,539
Costs: +20%	0%	($651)	-2%	($912)	18%	$717	17%	$1,008
Costs: +30%	-18%	($1,507)	<-30%	($2,042)	2%	($269)	0%	($523)
Benefits: -10%	16%	$187	15%	$199	37%	$1,547	37%	$2,308
Benefits: -20%	0%	($542)	-2%	($760)	18%	$597	17%	$840
Benefits: -30%	-18%	($1,159)	<-30%	($1,571)	2%	($207)	0%	($402)

42. **Private sector climate adaptive silviculture development**. The project will dedicate substantial capacity development and technology transfer resources to stimulate the establishment of effective nurseries adopting climate adaptive principles. The actual establishment of additional nurseries will be a complete private intervention. The project will stimulate by providing knowledge and technical assistance, and private entrepreneurs will invest own resources (or partly borrowed). For the establishment of a small scale nursery with 30,000 seedling / year capacity, the overall investment would be about 5,400 USD.

43. **Financial analysis**. Incorporating the possible effect of climate on the production, and for a 95 percent of marketable seedlings, the operation shows positive financial results, although it requires the deployment of own or loan resources to cover the initial years negative cashflow. Without loan, the 10 year IRR and NPV are respectively 52 percent and 9,600 USD. With a 5-year loan (12 percent interest) the IRR is 90 percent. The ideal condition is when the entrepreneurs access also to an additional short term working capital loan, which would reduce the negative cashflow to about 400 USD for the first two years (10-yrs NPV of 9,080 USD), possibly providing additional incentives to youth to enter the business.

44. **Economic analysis**. The stream of economic benefits would include the increased afforestation potential (with incremental afforestation costs, and carbon sequestration benefits). In order to account for such benefit, the actual sales of seedlings are converted in hectares. Tables 13.a and 13.b summarize the main results (including according to different carbon pricing), showing again that besides being a solid entrepreneurial opportunity, climate adaptive silviculture can also support the government in achieving the national NDC forest related targets.

Table 13.a. Economic benefits of climate adaptive silviculture activities.

Carbon Price = 40 USD / tCO2e

Scenarios	Nursery (20 years)	
	IRR	NPV
Base scenario	13%	34,710
Increase of costs by 10%	10%	22,792
Increase of costs by 20%	8%	10,874
Increase of costs by 30%	6%	(1,045)
Decrease of revenues by 10%	10%	19,321
Decrease of revenues by 20%	7%	3,932
Decrease of revenues by 30%	3%	(11,458)

Table 13.b. Economic benefits of climate adaptive silviculture activities.

Carbon Price = 10 USD / tCO2e

Scenarios	Nursery (20 years)	
	IRR	NPV
Base scenario	6%	246
Increase of costs by 10%	3%	(12,277)
Increase of costs by 20%	1%	(24,800)
Increase of costs by 30%	-1%	(37,324)
Decrease of revenues by 10%	3%	(12,302)
Decrease of revenues by 20%	0%	(24,850)
Decrease of revenues by 30%	-4%	(37,397)

Carbon Price = 5 USD / tCO2e

Scenarios	Nursery (20 years)	
	IRR	NPV
Base scenario	4%	(6,955)
Increase of costs by 10%	2%	(19,478)
Increase of costs by 20%	-1%	(32,001)
Increase of costs by 30%	-3%	(44,524)
Decrease of revenues by 10%	1%	(18,783)
Decrease of revenues by 20%	-2%	(30,610)
Decrease of revenues by 30%	-6%	(42,438)

45. **Private sector led beekeeping activities**. Even though the project will not mobilize ad hoc technical expertise on this, the forest investment will enhance the potential to establish small-scale commercial beekeeping activities. Two size have been analyzed: (a) 45 bee families; and (b) with 30 bee families. The long term success rate of entrepreneurial beekeeping is set at about 80 percent, as a combination of the relative sufficient basic knowledge on the operations with the need to operate it as a more risky commercial enterprise. The parameters are displayed in the Table 14 and show positive financial and economic benefits even with reduction of benefits by 30 percent, or equivalent increase of costs. Despite the initial investment determines a negative cash flow for over 5,800 USD, a 5 year loan can make the investment more attractive, down to an average cost of 500 USD / year in the first three years before starting to generate positive cash flows (slightly lower – about 340 USD/year, for the smaller scale model). This model is one of the possible examples of economic activity associated with improved forestry and its potential will constitute part of the incentives for the rural communities to maintain the forest throughout its growth period.

Parameters	Unit	Value
A. Medium Scale: Bee families	Bee family	45
B. Small Scale: bee families	Bee family	30
Long term success rate	%	80%
Production of honey by 1 family	kg/year	30
Production of wax by 1 family	kg/year	1.3
Maintenance of beehouses	%	10%
Sugar	kg/bee-family/year	5
Number of man-month for 60 bee-family business	man-month	12
Number of man-month for 30 bee-family business	man-month	5

Table 14. Financial and economic performance of beekeeping activity.

Sensitivity Analysis	45 bee-families		30 bee-families	
(10-years)	IRR	NPV	IRR	NPV
Base scenario	31%	5,917	31%	4,305
Increase of costs by 10%	25%	4,593	26%	3,408
Increase of costs by 20%	21%	3,269	21%	2,511
Increase of costs by 30%	17%	1,945	18%	1,615
Decrease of revenues by 10%	25%	4,001	25%	2,978
Decrease of revenues by 20%	19%	2,085	19%	1,650
Decrease of revenues by 30%	13%	170	13%	323

F. Aggregated results

46. **Aggregated results of the EFA**. The project aggregated benefits take into forest investment in 7,300 ha (including 1,300 ha under sustainable coppicing), the adoption by at least 9,000 hh of improved EE stoves, and at least 35 additional private enterprises for stove manufacturing, 40 new nurseries, 100 new beekeeping activities, and reduced forest degradation in at least 135,000 ha. The Financial analysis shows

a 20 year IRR equivalent to 13 percent, and corresponding NPV slightly below USD 1m. The rate of return is higher than the financial discount rate used as a relevant cost of capital for private investment decision (for the average loan rates for short-medium term credits the source is Central Bank of Armenia). The Economic analysis (which includes valuation of CO2e at 40 USD / tCO2e - as explained in section D above) shows a very high E-IRR (over 100 percent), with USD 271.2m NPV. The sensitivity to increase of costs or decrease of benefits shows also solid results: the financial NPV is negative in case of a twofold increase in costs or a drop of benefits by 45%. Economic results are substantially independent of costs and benefits, while they depend on the carbon pricing: when considering 10 USD / tCO2e (as the lowest range in the current carbon pricing initiatives), the E-IRR is 52 percent and NPV of USD 78.0m; at REDD+ pricing of 5 USD / tCO2e, the project still shows a solid IRR of 39% and a NPV of USD 46.0m. Considering the public nature of the forestry interventions, it is estimated that, without GCF grant, no investment would take place (including for private sector investments which would be triggered by the forestry investment and by the technology grant transfers to stimulate EE stoves adoption).

47. **Private investment leverage**. The total private investment that could be unlocked by the project is linked to the business opportunities related to the improved conditions of the forests (NTFP, Beekeeping, coppicing), to the public procurement in climate adaptive silviculture (nurseries for tree seedlings), as well as the production and adoption of EE heating stoves. Such amount (in Table 15) corresponds is estimated to be over 4 m USD (or over 4.5 m USD including the households investment in EE stoves).

Table 15. Private investment	USD / investment	Production units	Total Investment
Sustainable Coppicing	1700	1280	2,176,000
EE stoves adoption	50	9000	450,000
Stoves manufacturing	23020	35	805,700
Nurseries	5,375	40	215,000
Beekeeping	10500	100	1,050,000
TOTAL			**4,696,700**

48. **National savings from applying project forestry techniques**. The BAU practices for afforestation / reforestation present different aspects from the techniques proposed by the project (good international practices). For afforestation, seedling density used in BAU is between three and six thousand per ha, while the optimum proposed is about two thousand. Such density is ideal also to maximize the survival rate, reported to be at an average of 60 percent in BAU and estimated at 80 percent under the project. In the optic of achieving the NDC forestry targets, these difference have a major cost implication. In order to achieve the additional 300,000 ha of forests, the country will have to invest under BAU an amount of about 1.8 billion USD. Once mainstreamed and fully utilized in-country, while the cost of the full target reforestation would still remain high (about 1 billion USD), the project's approach can lead to saving about 800 million USD compared to BAU.

49. **An efficient carbon sequestration investment**. Overall, the project demonstrates efficiency in the achievement of its mitigation targets. The WB estimated social value of CO2e ranges between 40 and 80 USD per ton. Such level is considered the minimum required to stay consistent with achieving the temperature goal of the Paris Agreement (WB, 2017). A more recent study provides a review of carbon pricing actually applied by individual initiatives (government, international community – WB, 2018), showing prices varying between less than 10 (30 percent of the initiatives) to over 40 USD per tCO2e (20 percent of the initiatives). By taking the lowest price in this range, with an estimated removal of about 19.9 million tCO2e in 20 years, the project is able to generate a net incremental discounted value of about varying between 46 to 272 m USD (depending on the carbon pricing – respectively 5 USD and 40 USD per tCO2e – see Table 16).

Table 16. Aggregate economic performance, with different Carbon Pricing Scenarios

40 US$ / tCO2e		**With 10 US$ / tCO2e**		**With 5 US$ / tCO2e**	
IRR-Fin	**104%**	IRR-Fin	**52%**	IRR-Fin	**39%**
NPV-FIN	**$270,649,473**	NPV-FIN	**$78,333,591**	NPV-FIN	**$46,031,484**

Financial and Economic Performance – Base scenario

Investment:	Unit	Units	Outreach	Adoption / success	Financial Performance		Economic Performance	
					IRR	NPV	IRR	NPV
A/R in FL	ha	1	2350	80%	9%	(355,980)	15%	1,769,525
A/R in ML	ha	1	1000	survival	6%	(179,687)	11%	263,713
F-E in FL	ha	1	2350	rate	3%	(502,023)	7%	121,746
Sustainable Coppicing	ha	1.5	1600	90%	35%	1,349	65%	4,070
Private Nurseries (30,000 seedlings)	Enterprises	1	40	90%	52%	9,589	13%	34,710
Beekeeping (45 beehives)	Enterprises	1	100	85%	31%	5,917	44%	12,627
Local Stoves (52% EE)	HHs	1	9000	85%	39%	241	53%	472
Imported Stoves (60% EE)	HHs	1	9000	85%	46%	522	60%	1,017
Imported Stoves (70% EE)	HHs	1	9000	85%	47%	795	62%	1,534
Stoves manufacturing	Enterprises	1	35	85%	45%	45,095	56%	85,853

Financial and Economic Performance – Sensitivity Analysis

Investment:	Sensitivity Analysis	Financial Performance		Economic Performance	
		IRR	NPV	IRR	NPV
A/R in FL	-20% Benefits	7%	(564,004)	13%	1,454,405
A/R in ML	-20% Benefits	4%	(223,948)	10%	196,666
F-E in FL	-20% Benefits	1%	(564,431)	6%	27,210
Sustainable Coppicing	-20% Benefits	-2%	(760)	17%	840
Private Nurseries (30,000 seedlings)	-20% Benefits	37%	5,983	7%	3,932
Beekeeping (45 beehives)	-20% Benefits	19%	2,085	29%	7,615
Local Stoves (52% EE)	+20% Price	8%	20	13%	60
Imported Stoves (60% EE)	+20% Price	32%	329	51%	869
Imported Stoves (70% EE)	+20% Price	42%	699	59%	1,461
Stoves manufacturing	+22-30% Costs[13]	13%	603	8%	2,809

[13] 22% for financial and 30% for economic analysis

Appendix 1: Table of Content of Economic and Financial Analysis

Content of EFA	Link to the file here
Prices	Prices
Conversion Factors	CF
Forestry Investment Parameters:	
Afforestation-Reforestation in State Land: Technical Parameters	AR-FL_Para
Afforestation-Reforestation in State Land: Investment Costs	AR-FL_Costs
Afforestation-Reforestation in Municipality Land: Technical Parameters	AR-ML_Para
Afforestation-Reforestation in Municipality Land: Investment Costs	AR-ML_Costs
Forest Enrichment in State Land: Technical Parameters	FE-FL_Para
Forest Enrichment in State Land: Investment Costs	FE-FL_Costs
Summary of Project's Forestry investment costs	SUM_FoCosts
Forestry investment: analysis	
Forestry Investment benefits: Financial analysis	FIN_ForestryInv
Forestry Investment benefits: Economic analysis	ECO_ForestryInv
Hyantar nurseries: Technical assumptions	
Seedling production capacity (with/without GCF intervention)	Seedl.PrCap
Potential impact on forestry-related NDC targets	NDCTgts
Sustainable coppicing activities:	
Benefits of demonstration / capacity development	Coppicing_DEMO
Private coppicing enterprise: financial benefits	Coppicing-pv_FIN
Private coppicing enterprise: economic benefits	Coppicing-pv_ECON
Technology grant transfers (Energy efficient stoves)	
Adoption of EE stoves: financial benefits	EE stoves_FIN
Adoption of EE stoves: economic benefits	EE stoves_ECON
Manufacturing of EE stoves: financial benefits	StovesManuf_FIN
Manufacturing of EE stoves: economic benefits	StovesManuf_ECON
Additional economic opportunities related to forest restoration investment:	
Nursery development: financial benefits	Nursery-FIN
Nursery development: economic benefits	Nursery-ECON
Beekeeping: financial benefits	Beekeeping-FIN
Beekeeping: financial economic benefits	Beekeeping-ECON
Aggregated results:	
Aggregted financial results	Aggregated_FIN
Aggregated economic results	Aggregated_ECON
Additional tables - references:	
Forestry Investment Assumptions (Working Paper for GCF project)	Fo-Inv Assumpt.
Interest rates (Central Bank of Armenia)	CBA_i-rates
EX-ACT results reference (Working Paper for GCFproject)	EX-ACT tCO2e
GCF project costs (GCF Feasibility Study - Annex 3).	GCF-ProjectCost

Appendix 2: Carbon pricing

1. Carbon pricing is a priority issue for mitigation interventions and levels have already been leveraging private sector interest. As of now, there is no univocal pricing, neither on the financial side nor on the social-economic value of it. Nevertheless, the main Multilateral Development Banks have mainstreamed the carbon valuation in their operations and a summary of their positions is provided in the box below (source: State and Trends of Carbon Pricing, WB, May 2018). On the private sector side, there is a growing awareness that carbon market should be more developed, and the current levels (via taxations or other forms of compensation) are below the minimum levels required.

2. The World Bank has estimated that the social value of CO2e should range between 40 and 80 USD per ton between 2020 and 2080 (on a steadily growing pace), stating that this is the minimum social value of carbon required to stay consistent with achieving the temperature goal of the Paris Agreement. A subsequent analysis of the World Bank has also provided a range of values of individual carbon pricing initiatives. The assessment (summarizing the carbon pricing in the figure below) shows that about 40 percent of the initiatives value CO2e below 10 USD; another 40 percent ranges between 10 and 40 USD per ton; and the remaining 20 percent varies between 40 and 140 USD / t CO22.

3. By taking the lowest price in these ranges, the project (with an estimated production of about 19.9 million tCO2e) is able to generate a net incremental discounted value of about 46.9 m USD at 10 USD / tCO2e (minimum range of the currently existing carbon pricing). Considering the 40 USD / tCO2e (the minimum value carbon should have from 2020 onwards), such discounted value would amount 233.7 m USD.

Box. Compendium of Multilateral Development Banks' valuation of carbon

Asian Development Bank incorporates a social cost of carbon as part of the economic analysis of projects in the energy and transport sectors and projects with a GHG emission mitigation focus. In 2016, a carbon price of US$36.3/tCO2e was used, which increases annually by 2 percent in real terms to take the increasing marginal damage of climate change over time into account. The approach identifies and values the net change in emissions resulting from a given project through a 'with and without project' comparison.

European Bank for Reconstruction and Development (EBRD) has publicly disclosed its carbon pricing methodology for coal-fired power generation projects. The cost of emissions is factored in as part of the lifetime costs of the coal-fired power generation projects considered, along with other relevant externalities, and used to compare with different feasible alternative projects. The carbon price being applied starts at €35/tCO2e (US$43/tCO2e) for 2014 GHG emissions, rising by 2 percent per year in real terms. Since the introduction of the methodology, the EBRD has not financed any coal-fired power projects.

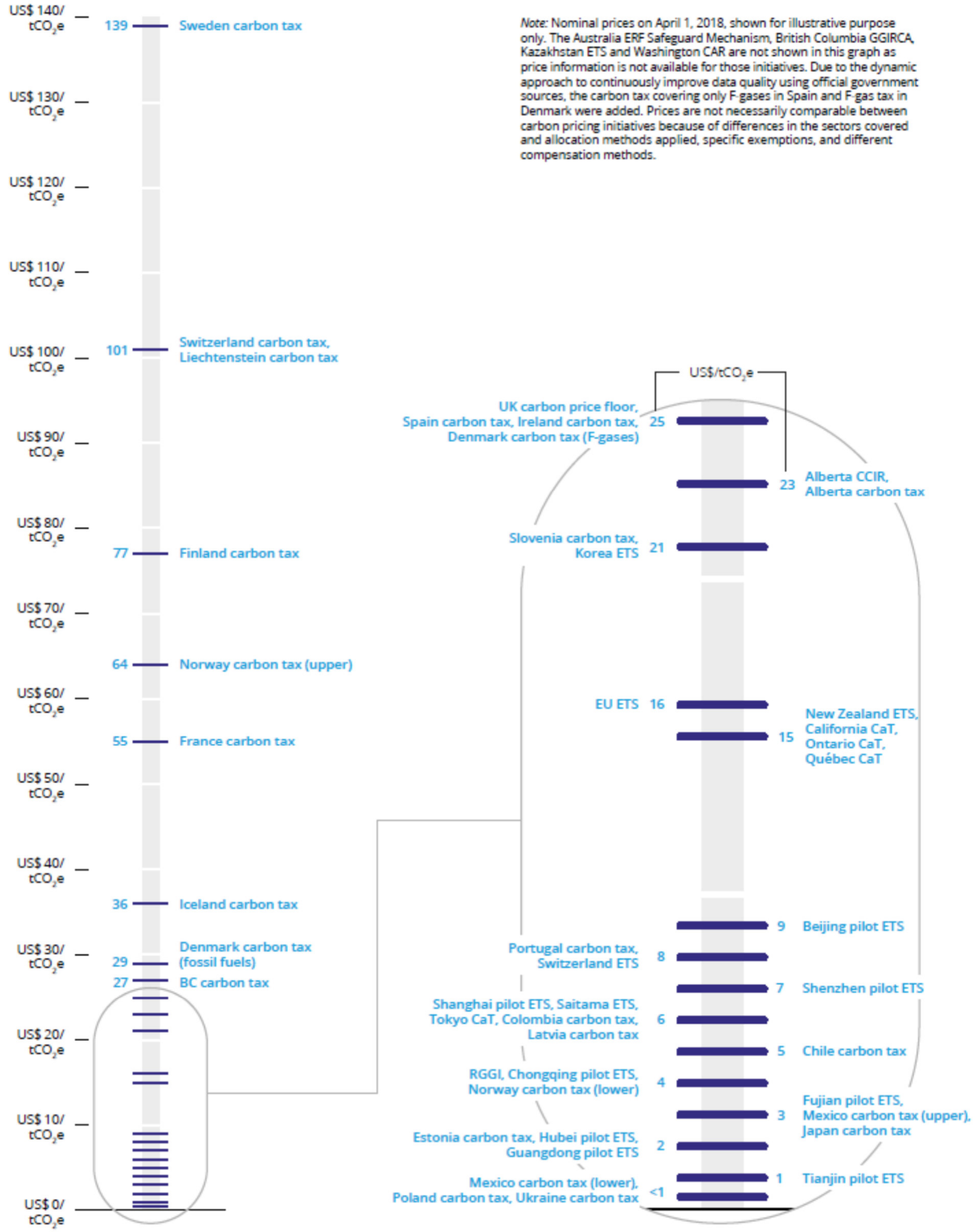
European Investment Bank (EIB) began to incorporate environmental externalities, including carbon and local air pollutants, into its economic appraisal of projects in the mid-1990s. The EIB, as part of its wider climate action strategy, has established internal carbon prices to 2050. The central EIB price for carbon emissions in 2018 is €38/tCO2e (US$47/tCO2e), increasing annually in real 2016 terms to €121/tCO2e (US$150/tCO2e) by 2050. The EIB also uses a low and high carbon price scenario in its sensitivity testing.

The World Bank updated its approach in September 2017 to align the carbon prices used with the Paris-compatible prices from the High Level Commission on Carbon Prices. The use of a shadow price of carbon in economic analysis is a corporate commitment for all International Development Association/ International Bank for Reconstruction and Development investment project financing in sectors that are subject to GHG accounting and that have concept notes approved on or after July 1, 2017. When conducting an economic analysis of projects, a low and high price is required, starting at US$40/tCO2e and US$80t/CO2e, respectively, in 2020 and increasing to US$50/tCO2e and $100/tCO2e by 2030. Beyond 2030, the price rises at a rate of 2.25 per cent per year to 2050.

The International Finance Corporation (IFC) has operated a carbon pricing pilot since November 2016 using price levels of US$30/tCO2e in 2016, increasing to US$80/tCO2e by 2050. The price is applied to the economic rate of return analysis of project finance investments in the cement, thermal power and chemicals sectors, and is considered as one of several inputs into the investment decision. The price is applied to gross Scope 1 and 2 emissions. The IFC is moving to full implementation in project finance deals in the three sectors listed above, and plans to pilot the application of a carbon price to project finance investments in other sectors with annual emissions above 25 ktCO2e.

(Source: WB, State and Trends of Carbon Pricing, May 2018).

Figure. Carbon pricing initiatives



(Source, WB 2018)