Food and Agriculture Organization
of the United Nations

India

Rice value chain analysis in Tamil Nadu, India

EX-ACT VALUE CHAIN CASE STUDY

Targeting climate change mitigation, resilience and income in a cocoa value chain with the Ex-Ante Carbon-balance Tool for value chains (EX-ACT VC)

This report is a case study of a multi-impact appraisal of a paddy value chain in India. The value chain is analysed from production to the distribution of rice into inner markets, comparing the performance of an upgrading scenario to the current situation. In the present case, farmers practice 1 to 3 rice crops a year (conventional rice). With the project, a more sustainable agro-ecological rice cultivation, namely Rice System Intensification (SRI), will be proposed to them. Adopting this methodology will improve water-use efficiency, soil conditions, household resilience to food security (high income, food availability and reduction in post-harvest losses) and self-organisation. Finally, the implementation of the SRI methodology on the project area will lead to a decrease in greenhouse gas (GHG) emissions (mainly CH_4 from rice cultivation) with a mitigation potential of about 4 tCO_2-e per hectare per year.

FAO/Joerg Boethling

KEY MESSAGES

- The shift from conventional rice cultivation to SRI allows GHG emissions reductions of up to 4 tCO_2-e per hectare per year due to changes in management practices at the production level.
- Socio-economic performances: the shift to SRI systems increases the value added generated at every level of the value chain, gross production value and gross income of all operators. The total number employed increases by cause of there being a higher task force at every stage of the chain. In total, about 6 140 jobs are created.

EX-ANTE CARBON-BALANCE TOOL ◢ EX-ACT

Background of the project – Rice systems in India

In India, the potential for improvement in agriculture performance has been identified in the region of Tamil Nadu, which hosts a large rural population dependent on crop production as a main source of income.

The proposed "Tamil Nadu Irrigated Agriculture Modernization Project" (TNIAMP) is a World Bank funded project that aims to enhance the productivity and resilience of irrigated agriculture and increase value-added for targeted beneficiaries in Tamil Nadu. With a planned implementation period of 2017 to 2027, the project focuses on increasing crop productivity and water-use efficiency, introducing crop and income diversification into non-paddy production systems and value-addition activities, as well as promoting climate-resilient farming practices and technologies.

TNIAMP aims at reducing the vulnerability of farming households, such as by increasing the access to adequate irrigation technology and supporting a sustainable intensification pathway. Numerous crops are considered in this project: flooded rice, dryland crops and horticulture crops. Specifically, one component of the project is to work toward supporting a large scale adoption of specific technologies on the major crops of each sub-basin identified in India. The System of Rice Intensification (SRI) and Precision Farming (PF) are the major components demonstrated in all the sub basins in the context of water saving and increased productivity.

The SRI is an agro-ecological methodology, with the concept of more outputs from less inputs, to (i) increase the productivity of irrigated rice by changing the management of plants, soil, water and nutrients; (ii) promote the growth of root systems; and (iii) increase the abundance and diversity of soil organisms. Consequently some of the reported benefits are an average 52 percent increase in yields, 128 percent of increased net income per hectare, a 44 percent reduction in production costs and a reduction in water requirement.

As EX-ACT VC only allows the analysis of one type of value chain, the present analysis will focus only on an upgrade from conventional rice production (1 to 3 rice crops) to a mix of conventional and more frequent use of the SRI methodology.

Methodology and tools used

EX-ACT VC tool

EX-ACT VC is a tool derived from EX-ACT (EX-Ante Carbon-balance Tool), developed by FAO in 2009. EX-ACT VC is an Agriculture, Forestry and Other Land Use (AFOLU), processing and transportation framework of 8 Excel modules that provides co-benefits appraisals of crop-based value chains in developing countries on GHGs emissions, climate resilience and income.

The EX-ACT VC aims at helping designing performant and sustainable value chains. The methodology provides both a quantified socio-economic appraisal of value chain both at micro and meso levels (by agent, by group and for the whole chain) and an environmental carbon-balance appraisal of the value chain impact, in terms of climate mitigation, adaptation and value chain resilience:

- **The impact on climate mitigation** is reflected through quantitative indicators, derived directly from the EX-ACT tool. These indicators are used to obtain and analyse the mitigation impacts in terms of tonnes of carbon dioxide equivalents (tCO_2-e) of the project. The carbon footprint of the product is calculated for the whole value chain and at different stages, in order to analyse the environmental performance of the chain. The equivalent economic return is also determined and could be an important aspect to be considered when attempting, for example, to access payments for environmental services.
- **Value chain resilience** is assessed using simple quantitative but also qualitative indicators. Adaptation indicators measure the reduction of vulnerability of people, livelihoods and ecosystems to climate change.
- **The socio-economic impact** of the value chain is assessed in terms of value-added, income and employment generation using a socio-economic appraisal component of the value chain.

EX-ACT tool

The Ex-Ante Carbon-balance Tool (EX-ACT) is an appraisal system developed by FAO providing ex-ante estimates of the impact of agriculture and forestry development projects, programmes and policies on the carbon-balance.

The carbon-balance is defined as the net balance from all GHGs expressed in carbon dioxide (CO_2) equivalents that were emitted or sequestered due to project implementation as compared to a business-as-usual scenario.

EX-ACT is a land-based accounting system, estimating carbon (C) stock changes (i.e. emissions or sinks of CO_2) as well as GHG emissions per unit of land, expressed in equivalent tonnes of CO_2 per hectare and year. The tool helps project designers to estimate and prioritize project activities with high benefits in economic and climate change mitigation terms. The amount of GHG mitigation may also be used as part of economic analysis as well as for the application for funding additional project components.

EX-ACT has been developed using mostly the Intergovernmental Panel on Climate Change 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) that furnishes EX-ACT with recognized default values for emission factors and carbon values, the so called Tier 1 level of precision. Besides, EX-ACT is based upon chapter 8 of the Fourth Assessment Report from working group III of the IPCC (Smith, *et al*., 2007) for specific mitigation options not covered in the IPCC (2006). Other required coefficients are from published reviews or international databases. For instance embodied GHG emissions for farm operations, transportation of inputs, and irrigation systems implementation come from Lal (2004) and electricity emission factors are based on data from the International Energy Agency (IEA, 2013).

Developing systems of rice intensification on paddy value chain in India

This analysis only focuses on the paddy value chain in the Tamil Nadu region of India, under Tropical Moist climate where high activity clay (HAC) soils are the dominant soil in the region. We assume that the implementation of the project started in 2017 for a duration of 10 years.

More specifically, the project of developing SRI in India is based on a mixture of intensive and less intensive systems (from 1 to 3 crops a year). Thus, this analysis will provide a complete comparison between intensive and less intensive conventional production and intensive and less intensive SRI systems.

The conventional production of paddy rice value chain currently concerns 106 830 ha of conventional rice (all systems included, i.e. 1, 2 or 3 crops), and 35 610 ha of SRI (25 percent of the total production). The project aims at reducing the conventional production (-73 percent) for developing SRI on paddy production (+320 percent).

Together with the shift by adoption of SRI on increased surface areas, farmers will apply more green manure, from 500 to 6 500 kg per hectare per year, while the use of urea, compost, SSP and KCl will remain constant between the current and the upgrading scenario. In the upgrading scenario, farmers will also supplement with herbicides the use of other “pesticides”, i.e. insecticides and fungicides.

Module: Agricultural practices

SRI is a flooded rice system, using intermittently flooded irrigation with a non-flooded preseason >180 days.

Implementing SRI implies a modification of the management options, more specifically on the water regime and the amendment type as compared to the conventional production of paddy (1 to 3 rice crops). A shift from the conventional 3 crops system to the 3 crops SRI methodology would change the yield from 10.2 t/ha to about 12.9 t/ha. Depending on the number of crops cultivated during the year, the area concerned by the project implementation changes for the upgrading scenario.

With better management practices adopted in the upgrading scenario, the production loss at this stage of the paddy will be reduced from 8 percent to 4 percent of the total production.

Figure 1. Details on the rice systems production (water regime, cultivation period, organic amend type) between conventional and SRI systems for the current and upgrading scenarios

3.1.3 Flooded rice systems remaining flooded rice systems (total area must remain constant)

Prod. loss	Cultivation period (days)	Water regime: In cropping season	Water regime: Before cropping	Organic amend type	Yield (t/ha/yr)	Area concerned: Current	Area concerned: Upgrading
Flooded rice from other LU							
Rice after Deforestation	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
Rice after non-forest LU	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment		0	0
Rice systems staying as rice syst.							
Conventional 3 crops	270	Irrigated - Continuously flooded	Flooded preseason (>30 days)	Straw incorporated long (>30d) before cultivation	10.2	27956	7122
Conventional 2 crops	180	Irrigated - Continuously flooded	Flooded preseason (>30 days)	Straw incorporated long (>30d) before cultivation	6.8	41599	11870
Conventional 1 crop	90	Irrigated - Continuously flooded	Flooded preseason (>30 days)	Straw incorporated long (>30d) before cultivation	3.4	37275	9496
SRI 3 crops	270	Irrigated - Intermittently flooded	Non flooded preseason <180 days	Compost	12.9	9319	28488
SRI 2 crops	180	Irrigated - Intermittently flooded	Non flooded preseason <180 days	Compost	8.6	13866	47480
SRI 1 crop	90	Irrigated - Intermittently flooded	Non flooded preseason <180 days	Compost	4.3	12425	37984
					Total area	142440	142440

Since the upgrading scenario involves higher mechanization for the development of SRI as compared to the actual situation, the consumption of diesel is increased roughly 30 percent, from 288 L/ha to 420 L/ha.

With the upgrading scenario, to target higher productivity, farmers will rely on an increase use of green manure only 500 to 6 500 kg/ha, while other fertilizers consumption will remain unchanged. Farmers will use also herbicides in the upgrading scenario. Figure 2 provides details of the fertilizers and herbicides inputs in the current and upgrading scenarios.

Figure 2. Details of the fertilizers and herbicides inputs in the current and upgrading scenarios

4.2. Crop-based input

4.2.1 - Fertilizer consumption at production level :

Please fill this part both for crop or feed crop (livestock)

List of specific fertilizers	Specify NPK parts (%): N	P	K	Current: Qty (Kg/ha/yr)	Current: Area (ha)	Upgrading: Qty (kg/ha/yr)	Upgrading: Area (ha)
Lime				0	0	0	0
Urea	47%			385	142440	385	142440
Other N-fertilizer	40%			0	0	0	0
N fertilizer in irrigated rice	38%			0	0	0	0
Sewage	5%			0	0	0	0
Compost	4%	1.5%	1.2%	2500	142440	2500	142440
Phosphorus synthetic fertilizer (P2O5)		10%		0	0	0	0
Potassium synthetic fertilizer (K2O)			10%	0	0	0	0
Please enter your specific NPK synthetic fertilizer (N other than urea and not for irrgated rice)							
SSP	0%	22%	0%	308	142440	308	142440
KCL	0%	0%	63%	83	142440	83	142440
Green manure	0%	2%	1%	500	142440	6500	142440
Description#4	0%	0%	0%	0	0	0	0
Description#5	0%	0%	0%	0	0	0	0

4.2.1 - Pesticides consumption at production level :

Type of pesticides	Current: Qty (kg/ha/yr)	Current: Area (ha)	Upgrading: Qty (kg/ha/yr)	Upgrading: Area (ha)
Herbicides (kg of active ingredient per year)	0	0	2	142440
Insecticides (kg of active ingredient per year)	2	142440	2	142440
Fungicides (kg of active ingredient per year)	3	142440	2	142440

Processing module

Milling is a crucial step in the post-production process of rice. The basic objective of a rice milling system is to remove the husk and the bran layers, and produce an edible, white rice kernel that is sufficiently milled and free of impurities.

We assume that 21 percent of the production is self-processed and consumed locally, not involving local processing facilities. Therefore only 79 percent of the production undergoes processing. The energy consumption, which we assume as constant between the two scenarios, represents an average of 5 liters of gasoline per tonne of production. Only jut bags are used for packing the production before transportation to wholesaler which represent around 20 kg per tonne of paddy.

Finally, one of the actions possible at processing level is better management of the production to reduce loss. At processing level, we assume a reduction from 2 to 1 percent of production loss and an increase in the processing rate from 67 percent to 68 percent.

Transportation

The present analysis only focuses on the transportation within the country of production, from the producers to the local market; international exportation is therefore excluded. Trucks are the main type of transportation used and the average distance travelled between the different stages of the value chain are 35 km from farm to processing/storage, 70 km in average between processing and wholesaler and others, and 70 km between wholesalers and retailers. No conditioning is used for transporting rice.

Within the upgrading scenario we assume a decrease of the production loss at transportation level from 3 percent to 1.5 percent, increasing the availability of food on the local market.

Socio-economic analysis

In this module, information provided in the previous EX-ACT VC modules is automatically filled out, and cost information is addressed only where needed. All prices are entered in local currency and converted in USD according to the currency exchange rate. Concerning the employment in SRI systems, we assume an increase of man-days needed per hectares for the production without any change in the salary.

Selling prices remain the same at the different stages of production for both situations. Prices of agricultural and energy inputs, salary costs, taxes and other costs throughout the different stages (i.e. production, processing, transport) need to be provided. Basic economic information for the wholesalers and retailers are required if available (cost rent, cost of a salary for an assistant). Details of the socio-economic analysis for the production stage are shown in Figure 3.

Figure 3. Details of the socio-economic analysis for the production stage

Phosphorus synthetic fertilizer (P2O5)	0	kg	0	0.0
Potassium synthetic fertilizer (K2O)	0	kg	0	0.0
SSP	308	kg	4	18.4
KCL	83	kg	15	18.6
Green manure	500	kg	1	7.5
Description#4	0	kg	0	0.0
Description#5	0	kg	0	0.0
			only prices to enter	
Pesticides				
Herbicides	0	kg of active ingredient per year	0	0.0
Pesticides	2		489	14.6
Fungicides	3		348	15.6
Fuel consumption in liter per hectare per year				
Gasoil/Diesel	2.02190396	liter	44	1.3
Gasoline	0	liter	0	0.0
Gas (LPG/ natural)	0	liter	0	0.0
Butane	0	liter	0	0.0
Propane	0	liter	0	0.0
Ethanol	0	liter	0	0.0
Please fill if other	0	liter	0	0.0
Electricity (kWh per hectare per year)	0	kWh	0	0.0
Other than taxes and credit cost			2100	31.3
Labor cost				
Crop production (man-days/ha)			Salary per man per day	cost per year per ha
% of family labour	0%			
Land preparation-tillage	13		134	26.0
Seeding- input procurement	15		134	30.0
Weeding - treatment	12		134	24.0
Manure- compost delivery	4		134	8.0
Harvesting- farm transport	15		134	30.0
Other tasks	12		134	24.0
Total man-days per ha	71			
Total cost per ha per year				**302.4**

Phosphorus synthetic fertilizer (P2O5)	-	0.0
Potassium synthetic fertilizer (K2O)	-	0.0
SSP	308	18.4
KCL	83	18.6
Green manure	6,500	97.0
Description#4	-	0.0
Description#5	-	0.0
Pesticides		
Herbicides	2.00	0.0
Pesticides	2.00	14.6
Fungicides	2.00	10.4
Fuel consumption in liter per hectare per year		
Gasoil/Diesel	2.95	1.9
Gasoline	-	0.0
Gas (LPG/ natural)	-	0.0
Butane	-	0.0
Propane	-	0.0
Ethanol	-	0.0
Please fill if other	-	0.0
Electricity (kWh per hectare per year)	-	0.0
Other than taxes and credit cost		31.3
Labor cost	We assume the wage won't change within the upgrading scenari	
Crop production (man-days/ha)		cost per year per ha
% of family labour	0%	
Land preparation-tillage	9	18.0
Seeding- input procurement	23	46.0
Weeding - treatment	22	44.0
Manure- compost delivery	5	10.0
Harvesting- farm transport	16	32.0
Other tasks	5	10.0
Total man-days per ha	80	
Total cost per ha per year		**405.4**

Climate resilience analysis

The scope here is to specify an assessment between 0 and 4 for every questions asked in this module based on the judgment of project experts. It is a qualitative appraisal of the extent of the upgrading scenario on the buffer capacity of the rice value chain to natural shocks, of the households in relation to food security, the resilience and the self-organization of households, and the market resilience and the adaptation capacity of the value chain. An assumption for every sub-index was done in this case, but is open to debate.

Results of the ex-ante value chain appraisal

Climate mitigation dimension

In the present analysis, we assumed that there would be no changes in energy and inputs used in the processing phase and the transport between the current situation and project implementation. Therefore, changes in GHG impact between the two scenarios are due to changes in rice management practices (length of water regime and organic amendment employed) and agricultural inputs.

Over the whole duration of the VC analysis, i.e. 10 years, conventional rice cultivation, for which soils are continuously flooded with a flooded pre-season of more than 30 days, is a source of about 2.7 million tCO_2-e. With the implementation of the new agro-ecological methodologies (SRI), the GHG impact of the upgrading scenario is slightly lower, about 2.2 million tCO_2-e. Emissions as methane (CH_4) are coming from the decomposition of organic matter in an anaerobic environment created by waterlogged soils. With implementation of SRI methodologies, soils are waterlogged over a shorter time period, while compost is used as organic amendment instead of the straws. Combined together, this allows for the reduction of inputs of organic matter and consequently CH_4 emissions. At the production level, the potential of mitigation of the project is thus about -533 000 tCO_2-e, or 15tCO_2-e per hectare per year.

Figure 4. Details of the climate mitigation dimension of the value chain

Climate Mitigation dimension of the Value Chain	Current	Upgrading	Balance
GHG impact (tCO_2-e per year)	2,732,053.4	2,199,374.3	
GHG impact (tCO2-e per year per hectare)	19.2	15.4	-3.7
Carbon footprint of production (tCO_2-e per tonne of product)	2.7	1.9	-0.9
Annual tCO_2-e [emitted (+) / reduced or avoided (-)]		-532,679.1	
Annual tCO_2-e from renewable energy		0.0	
Equivalent project cost per tonne of $CO_{2\text{-}e}$ reduced or avoided (in US$ per tCO_2-e)		0.0	
Equivalent value of mitigation impact per year (US$ 30/tCO_2-e)		15,980,373.1	
Equivalent value of mitigation impact per year per ha (US$ 30/tCO_2-e per year per ha)		112.2	

Methane reduction is also reflected in the rice carbon footprint at the production level, from 2.7 to 1.9 tCO_2-e per tonne of production.

As no changes in energy and inputs consumption occur between the current and upgrading scenario at the processing and transport level, the emissions is respectively 0.01 and 0.32 tCO2-e per tonne of product in both scenarios. The rice carbon footprint from production, processing, and transport combined is 3.1 2 tCO_2-e per tonne of rice in the current scenario and 2.2 tCO_2-e per tonne of rice in the upgrading scenario. Thus, a decrease of 0.85 tCO_2-e per tonne of rice produced is achieved.

Figure 5. Details of the carbon footprint at the different levels of the value chain

Carbon footprint at the different levels of the Value Chain	Emissions (tCO2/t product)		Balance
	Current	Upgrading	
PRODUCTION	2.75	1.89	-0.85
PROCESSING	0.01	0.01	0.00
TRANSPORT	0.32	0.32	0.00
RETAIL	0.00	0.00	0.00
TOTAL	3.08	2.22	-0.85

This reduction in GHG emissions can also be assessed in terms of economic returns. Such indicators are only present for the value chain upgrading scenario. Considering a carbon market value of 30 USD (Figure 4), the implementation of SRI systems allows 112 USD per hectare per year to be earned. This can be used to seek access to payments for environmental services.

Socio-economic performance of the value chain

The shift from traditional rice to SRI increases the value-added generated at every level of the value chain, gross production value and gross income available for farmers and operators along the rice chain (Figure 6). The value-added per hectare of product increases from 1 778 to 2 053 USD at the production level between the two situations (+275 USD per hectare with SRI).

However, the value-added generated per tonne of paddy rice produced within the upgrading scenario decreases lightly (-8 USD/tonne) due to a higher need for mechanization (increased fuel consumption) and production input (green manure and herbicide). This is compensated in the production phase by the efficiency of the system since the gross income generated is higher within the upgrading scenario (+ 512 USD/farmers). This is attributed to the increase in the total production harvested during the year (+16 percent).

Adding to this, the volume of employment generated increases within the upgrading scenario due to the higher need of work force in the SRI scenario at every stage of the chain. In total, about 5 128 jobs are created in the production level and 433 jobs are created at the processing and upstream transportation level.

Figure 6. Details of the socio-economic performances of the value chain at the production and processing & transportation levels for the current and upgrading scenarios

	Socio-economic performances of the value chain	Current	Upgrading	Balance	
	Production level				
	Nb of HH	0	71220		
	Nb of employement-eq	40453	45581	5128	jobs
16%	Gross production Value (GPV)	271683	322863	51180	000 US$
13%	Value Added (VA)	253297	292375	39078	000 US$
14%	Gross Income (GI)	233071	269585	36514	000 US$
-3%	VA / tonne of product	279	271	-8	US$
13%	VA / ha	1778	2053	274	US$
14%	Gross income / HH	3273	3785	513	US$
	Processing and upstream transportation level				
	Nb of operator-eq	359	355		
	Nb of employement-eq	2297	2730	433	Jobs
26%	Gross processed production value (GPPV)	51844	69617	17773	000 US$
27%	Value added	48379	66287	17908	000 US$
10%	Gross income	45919	51144	5225	000 US$
11%	VA / tonne of product	103	115	13	US$
11%	Gross income / operator	127941	143892	15951	US$

Climate resilience dimension and index of the value chain

In terms of climate resilience (Figure 7), the whole project surface is managed under climate resilience practices as it concerns irrigated surfaces. Although the surface area of irrigated rice under project implementation, i.e. applying SRI practices, is about 113 952 hectares, the remaining surface under conventional practices emits higher levels of CH_4 compared to the SRI surfaces. This is due to a longer period of waterlogged soil and straws being used as organic amendment, contributing to higher organic matter available in the soils, which enhances anaerobic processes.

The low resilience index is explained by a low buffer capacity of project area and crop production. Indeed implementation of SRI methodology improves efficient use of water and soil conditions, and at the production level, reduces crop failure, disease and decreases post-harvest losses (from 8 to 4 percent). The project benefits mostly at the households level with a medium buffer capacity in relation to food security by increasing income, food availability and agricultural skills. It also finally moderately improves the self-organisation of the households building up local knowledge, fostering cooperation among farmers, and last but not the least by actively involving farmers in project implementation and adoption of new agricultural climate resilient practices.

Figure 7. Climate resilience dimensions and index with the implementation of SRI methodologies

Climate Resilience dimension (s)	Upgrading		
Hectares of land managed under climate-resilient practices	142,440	ha	113952
Hectares with improved tree and vegetal coverage (land slide, flood resilience)	0	ha	
Number of hectares with increased soil carbon (drought and erosion resilience)	0	ha	
Number of HH having become more climate resilient	71,220	HH	

Resilience index of the value chain upgrading	Upgrading		
Buffer capacity of watershed and landscape and project area	low	Buffer capac	1.8
Buffer capacity of crop -livestock production	low	buffer capac	1.1
Buffer capacity of households in relation to food security	medium	Buffer capac	2.4
Self-organisation of households	medium	Self-organis	2.4
Learning capacity of households	low	Learning ca	2.4
Global climate resilience generated by Value chain	**low**		

Conclusion

Implementation of the SRI methodology in substitution of conventional rice, which is highly dependent on water and agricultural inputs associated with high CH_4 emissions, positively impacts the value chain from producers (households), processors and downward operators. The main impacts are a mitigation potential of about -3.7 tCO_2-e per hectare per year, an increase of gross income per household by 14 percent, strengthening of household resilience in food security and self-organization, an increase annual yield by 15 percent and lowering the carbon footprint from 3.1 to 2.2 tCO2-e per tonne of product. The analysis highlighted the mitigation potential of simple agricultural practices such as reducing the time period of waterlogged soil and use of available local organic amendment on GHG emissions.

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EX-ANTE CARBON-BALANCE TOOL [EX-ACT]

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The authors thank the World Bank for the materials provided and for the support granted for the project analysis.

EX- ACT VALUE CHAIN STUDIES

This report is part of a series of brief, presenting project appraisals for value chain studies using either the EX-ACT VC Tool, which provides the potential climate change mitigation impacts, climate resilience, income and creation of jobs from investment projects in the Agriculture, Forestry and Land Use (AFOLU) sector. Each brief provides a short description of the project analyzed, the main results obtained and the related materials (case study document, EX-ACT VC screenshot).

I8367EN /1/07.19