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EASYPol Module xxx

Carbon Balance pre-appraisal on Russia Forest Fire Response Project

Application at a design stage of the *EX-Ante* C-balance Tool (EX-ACT version 3.3)

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Carbon Balance pre-appraisal on Russia Forest Fire Response Project

Application at a design stage of the EX-Ante C-balance Tool (EX-ACT version 3.3)

by

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TABLE OF ABBREVIATIONS

AFOLU	Agriculture, Forest and Other Land Use
CC	Climate Change
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon Dioxide
DM	Dry Matter
EX-ACT	EX-Ante Carbon-balance Tool
FAO	Food and Agriculture Organisation of the United Nations
FERP	Forestry Emergency Response Project
GHG	Green House Gas
GWP	Global Warming Potential
HAC	High Activity Clay
IPCC	Intergovernmental Panel on Climate Change
LAC	Low Activity Clay
MRV	Monitoring, Reporting and Verification
Mt	Million metric tons
N_2O	Nitrous Oxide
tCO_2-e	Ton of CO_2 equivalent
UNFCCC	United Nations Framework Convention on Climate Change

1. INTRODUCTION

Objectives

This paper identifies and interprets the main impacts of climate change mitigation, with the Ex-Ante Carbon Balance Tool (EX-ACT) on the Forestry Emergency Response Project (FERP). The analysis is based upon past reports, data and opinions from experts. It is nonetheless important to highlight the fact that this is an example of how a carbon a balance can be performed on a forestry project. It is hence not a real case study. The paper primarily describes EX-ACT (Ch. 2), followed by the country background (Ch. 3). Further, chapter 4 presents the FERP followed by the assumptions and data collection behind the analysis (Ch. 5). Chapter 6 illustrates the primary results of the analysis. The economic analysis is discussed in chapter 7. Chapter 8 concludes the paper.

Target audience

This document particularly aims at current or future practitioners working on the formulation and analysis of investment projects and climate change issues. It also targets workers in public administrations, NGO's, professional organizations or consulting firms. Academics can also find this material useful to support their courses in carbon balance analysis and development economics.

Required background

To fully understand the content of this document the user must be familiar with:
- Concepts of climate change mitigation and adaptation;
- Concepts of land use planning and management.

Readers can follow links included in the text to other EASYPol modules or references[1]. See also the list of EASYPol links included at the end of this module[2].

2. THE EX-ANTE CARBON-BALANCE TOOL (EX-ACT)

EX-ACT is a tool developed by FAO. The tool is aimed at providing ex-ante estimates of the impact of agriculture and forestry development projects/policies/programmes on GHG emissions and carbon sequestration. (Bernoux et al., 2010). The C-balance[3] is selected as indicator of the mitigation potential of the project/policy/programme. EX-ACT can be used in the context of ex-ante project formulation and has the ability to cover a range of projects relevant for the land use, land use change and the forestry sector. It can compute the C-balance by comparing different scenarios: "without project", i.e. the "Business As Usual" or "Baseline" and "with project". The main output of the tool consists of the C-balance resulting from the difference between the "with project" minus the "without project" scenario.

EX-ACT was developed mainly using the Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) complemented with other methodologies. Most calculations in EX-ACT use a Tier 1 approach[4] (Bernoux et al., 2010). This, as default values are proposed for each of the five

[1] EASYPol hyperlinks are shown in blue, as follows:
a) training paths are shown in **underlined bold font**
b) other EASYPol modules or complementary EASYPol materials are in ***bold underlined italics***;
c) links to the glossary are in **bold**; and
d) external links are in *italics*.

[2] This module is part of the EASYPol Resource Package: Macroeconomic, agricultural, trade and development policy, module1: macroeconomics and instrument of protection.

[3] C-balance = GHG emissions -carbon sequestered above and below ground.

[4] IPCC Guidelines provide three methodological tiers varying in complexity and uncertainty level: Tier1, simple first order approach which uses data from global datasets, simplified assumptions, IPCC default parameters (large uncertainty); Tier 2, a more accurate approach, using more disaggregated activity data, country specific parameter values (smaller uncertainty); Tier 3, which makes reference to higher order methods, detailed modeling and/or inventory measurement systems driven by data at higher resolution and direct measurements (much lower uncertainty).

pools[5] defined by the Intergovernmental Panel on Climate Change (IPCC) guidelines and the United Nations Framework Convention on Climate Change (UNFCCC). EX-ACT also allows users to incorporate specific coefficients with the Tier 2 approach from e.g. the project area, in case they are available. EX-ACT measures carbon stocks and stock changes per unit of land, as well as Methane (CH_4) and Nitrous Oxide (N_2O) emissions expressing its results in tons of Carbon Dioxide equivalent per hectare ($tCO_2eq.ha^{-1}$) and in tons of Carbon Dioxide equivalent per year ($tCO_2eq.year^{-1}$).

EX-ACT consists of a set of Microsoft Excel sheets in which project designers insert information on dominant soil types and climatic conditions of project area together with basic data on land use, land use change and land management practices foreseen under projects' activities as compared to a business as usual scenario (Bernoux et al., 2010).

3. BACKGROUND

According to MARF (2009), Russia is the largest country in the world (17 million square km or 1.7 billion ha) and has the largest area of closed forests (7.6-7.7 million square km or 0.76-0.77 billion ha). The latter represents 22 percent of the world's forests. More recently, the Russian Federation defined a Forest Land Fund: according to the Legislation, this category of land includes forest and non-forest land. Forestland includes parcels that are covered with forest vegetation (forested land) and parcels that are not covered with forest vegetation, but are meant for the forest restoration, e.g. clear cuts and burns. Non-forest land also includes land serving for the forest management, such as roads and rides for instance.

These intact forests are arranged in large arrays. (MARF, 2009). The forest land share of the forest-tundra sparse forest and taiga zone is 18%, northern taiga sub-zone 18%, middle taiga sub-zone 31%, southern taiga sub-zone 22%, coniferous-broadleaf forest zone 9%, and the steppe forest zone 2%. In terms of geographical location, the far eastern forest accounts for 17.6% of the total biomass stock *(cf. figure 1)*.

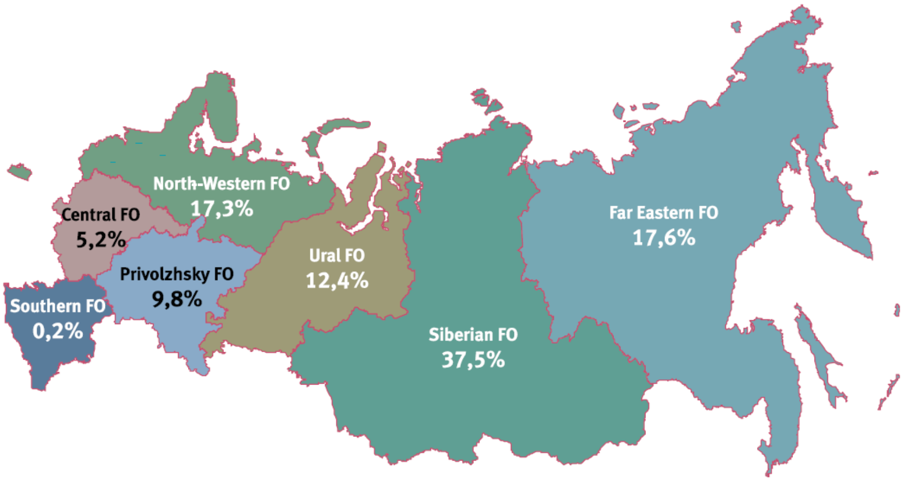

Figure 1. Distribution of forest resources among regions, % of total stock (MARF, 2009)

Fire is a major natural disturbance in Russian natural ecosystems, in particular in forests, due to: (1) a vast extent of natural ecosystems in Russia – forest, wetlands, grasses and shrubs; these comprise almost 90% of all vegetative areas; (2) about 95 percent of Russian forests are boreal forests, and 71% of them are dominated by coniferous stands of high fire hazard; (3) a significant part of the forested territory is practically unmanaged and unprotected, with large fires (>200 ha) having higher occurence; (4) a slow decomposition of plant residues, thus leading to natural ecosystems containing large amounts of accumulated organic matter; and (5) a major part of natural ecosystems that are situated in regions with limited amounts of

[5] Above-ground biomass, below-ground biomass, soil, deadwood and litter

precipitation and/or frequent occurrences of long drought periods during the fire season, often initiating fires of high severity (Shvidenko et al[6]., 2011).

Weather instability has increased recently. Periods with heavy rain alternate with prolonged warm and dry periods, sometimes followed by anomalous heat waves, e.g. summer of 2010 in European Russia. Such climatic variability has negative impacts upon large forested areas, essentially posing threats in the form of forest fires of high intensity, so called catastrophic fires (World Bank PID, 2012). Every year a vast area of Russian forest burns, ranging from 3 to 15 million ha according to satellite imagery (MARF, 2009). Nearly 90% of Russia's forest fires are of human origin. Figure 2 illustrates the ignition causes of forest fires caused in 2008 (MARF, 2009). Related to forest fires, a recent study by Shvidenko et al (2010) assessed the average output of carbon as a result of natural and human-induced fires in Russia. The authors reported that the inter-annual variability of carbon emissions is ranging from 50 Tg C year-1 (2000) to 231 Tg C year-1 (2003). This implies that there are large GHG emissions related to forest fires, directly having a negative impact on the climate and environment.

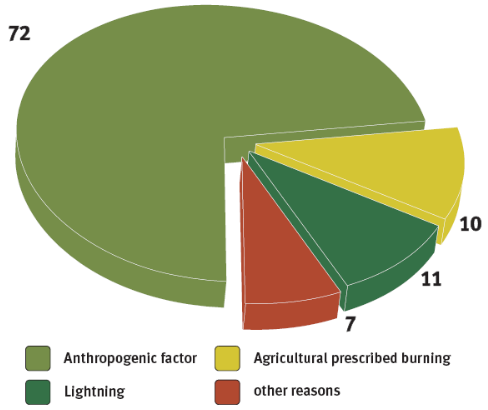

Figure 2. Forest fires and ignitions causes in % (from MARF, 2009)

Current models predicts that: (1) future fire regimes in the boreal zone are supposed to double by the end of this century; (2) substantial increase of catastrophic and escaped[7] fires; (3) dramatic increase of the intensity of fires and related GHG emissions; (4) and change of composition of products of burning due to a wider distribution of deep soil burning. (Shvidenko et al., 2011). Very likely, thawing of permafrost and aridization of landscapes on permafrost will lead to degradation and death of coniferous forests and to a wider distribution of "green desertification". There is a high probability of positive feedback between global warming and the escalation of fire regimes: the increase of CO_2eq in the atmosphere will lead to an increased frequency of long and dry periods.

Historically, the Soviet Union was advanced in terms of forest fire identification and suppression as they had approximately 600 aircrafts, 8,000 smokejumpers, and 70,000 full time forest guards. (Shvidenko et al., 2011). This capability was dissolved due to budget cuts after the dissolution of the Soviet Union. Consequently, there was a decline of 70% in aircraft flight hours for the purpose of fire control between 1991 and 2002. In parallel, over the same period, the percentage of fires detected by aviation has decreased by 45%. In addition, the average size of fires consistently increased from 1991 to 2002 as a result of shrinking fire management resources.

These negative trends were exacerbated as an unintended consequence of a major reform embodied in a new Forestry Code, which took place on January 2, 2007. (World Bank PID, 2012). This code completely decentralized the responsibility for decreasing and ceasing forest fires to the 89 federal subjects of the Russian Federation [including the 21 republics, 46

[6] Shvidenko et al, Carbon Emissions from Forest Fires in Boreal Eurasia between 1998-2010, 2011

[7] An escape fire is a fire lit to clear an area of vegetation in the face of an approaching wildfire when no escape exists. Like a backfire, it works by depriving an approaching primary fire of fuel so that when the primary fire reaches where the escape fire started the primary fire cannot continue; there is nothing there to burn.

oblasts (provinces), 9 krais (territories), and autonomous districts and cities]. Furthermore, the removal of any central authority annihilated the ability to shift resources in real time from regions free of severe fire stress to those suffering from overwhelming attacks.

4. THE FOREST EMERGENCY RESPONSE PROJECT DESCRIPTION

The proposed objective of the Forestry Emergency Response Project proposal[8] (FERP) is to improve forest fire prevention and management and enhance sustainable forest management. (World Bank PID, 2012). Furthermore, the project will contribute to raise public awareness and education standards in general forestry related issues, with a specific reference to forest fire prevention/control and forest governance issues. Given that the bulk of fires are of human origin, the latter is as important as the suppression of fires underway.

The FERP project has three components: (1) enhancing forest fire prevention, management and control; (2) building forest management capacity; and (3) project management. (World Bank PID, 2012). There will be two implementing agencies for the project: the Federal Forest Agency (FFA), which covers the extensive area forest of forest fund, and the Ministry of Natural Resources and Environment (MNRE), which will implement the project in Protected Areas (PAs).

The following specific activities and measures envisaged within the project include (World Bank PID, 2012):

1. Improving ground-based forest fire response, and the reconstruction, modernization and maintenance of forest fire stations in 3 – 5 pilot regions;
2. Establishment of local forest fire brigades and firefighting, with the providence of communication equipment;
3. Inter-regional Forest Fire Centers, e.g. in the Far East, Siberian, and Northwestern Federal Districts. Those will be equipped for the detection and suppression of large-scale fire outbreaks, coordination of response between regions and agencies, as well as pest treatment;
4. Public awareness and education programs and products, e.g. brochures, school curricula, posters, radio and TV media, websites, blogs, mainly developed to advocate forest fire safety rules;
5. Strengthening of early fire detection and response by upgrading the fire danger rating and hazard index systems in pilot regions and Protected Areas. It also includes the expansion of network ground-based fire services, counting fire towers and observation points in key target areas;
6. Enhanced fire fighting preparedness in targeted Protected Areas through the upgrading of forest fire stations, constructing and cleaning firebreaks. Such activities will be aligned with respective park management plans.

Physical interventions will focus on 5 pilot regions: Khabarovsk Kray, Komi Republic, Krasnoyarsk Kray, Moscow Oblast, and Voronez Oblast. (World Bank PID, 2012). Within these regions, the following targeted protected areas are:

- Meschera, Okskiy, and Meshcherskiy in the Central Federal Okrug;
- Kerzhensky, Buzuluskiy, Zhigulevskiy, and Samarkskaya Luka in the Volga Federal Okruy;
- Sayano-Shushenskiy, Stolby, and Shushkenskiy Bor in Krasnoyarsk Kray (Siberian Federal Okrug) and;
- Bureinkiy, Komsomolskiy, and Bastak in the Far East Federal Okrug).

These regions have been selected by a project design team according to geographic, economic, and environmental criteria's. In addition, the project's geographical focus is on forests with high environmental or economic value, which may be situated close to settlements or infrastructure. Hence a fire in this area implies an increased risk regarding human life loss,

[8] This part is mostly derived from the Project proposal draft

severe human health impacts, and substantial damage to infrastructure, loss of economic assets or valuable ecological resources, e.g. national parks. Within this wide scope of targeted areas, it is expected that the project impact should progressively enlarge to neighbor areas and reach a quasi-national coverage.

5. STRUCTURE AND BASIC ASSUMPTIONS OF THE ANALYSIS

This is an exercise that illustrates how EX-ACT can be applied within the context of the Forestry Emergency Response Project. Therefore, various assumptions are taken within the analysis mainly based upon an expert meeting that took place in Moscow, end of 2010. Further, the analysis was based upon past reports from the Project Information Document (PID) of the World Bank (2012) followed by diverse reports (MARF, 2009; MNRRF-SFF, 2003).

5.1 Fixed parameters of the carbon appraisal

In order to appraise the carbon balance of this project, information on soil and climate are needed to better define the carbon storage. The soil and climate characteristics were defined according to the IPCC climate zones and the World Resource Base (WRB) soil maps that can be found in the EX-ACT tool.

Accordingly, the soil was classified as **High Activity Clay** (HAC) and the average climate as **Boreal** with a **moist** regime. The time frame chosen for the analysis is **25 years**. In the analysis it is assumed that the implementation phase lasts 5 years, thus with a capitalisation set to 20 years.

Regarding the Global Warming Potential (GWP) coefficients[9], the present analysis uses the same values as those adopted within the Clean Development Mechanism (CDM), i.e. 21 for CH_4 and 310 for N_2O. Figure 3 illustrates the overall description of the project, extracted from EX-ACT.

Project Name	*Forest Fire Response project*	
Continent	Asia (Continental)	
Climate	Boreal	
Moisture regime	Moist	
	See "Climate" for Help	
Dominant Regional Soil Type	HAC Soils	
	See "Soil" for Help	
Duration of the Project (Years)	Implementation phase	5
	Capitalisation phase	20
	Duration of accounting	25

Figure 3: Description of the FERP

5.2 Assumptions for the Baseline (BAU scenario)

Table 1 represents the average yearly-fired areas burnt from 1998 to 2010. The annual mean burnt forest area for the 13-year period is 4,886,000Ha. Therefore, it was assumed that without project implementation the area burnt annually is equal to 4,886,000ha.

[9]The GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale, which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is by convention equal to 1.

Table 1. Average fired areas per year and related carbon emissions 1998-2010 by land type

Vegetation	Area, 10^3 ha	Emission, 10^3 t C	including the main emission species, 10^3 t C							
			CO_2	CO	CH_4	NMHC	OC	BC	$PM_{2.5}$	TPM
Forest	4,886.0	82,036.0	68,819.8	6,919.7	836.3	598.8	834.9	82.0	878.1	1,284.6
Arable	402.0	606.3	524.3	46.8	6.8	5.8	3.0	0.6	4.9	7.9
Hayfield	320.4	778.1	671.7	60.8	9.0	7.5	3.9	0.8	6.3	10.2
Pasture	498.4	933.2	810.0	70.3	10.1	8.6	4.7	0.9	7.3	12.0
Fallow	72.1	136.1	118.8	9.8	1.3	1.2	0.7	0.1	1.0	1.7
Abandoned arable	261.4	564.0	491.6	41.2	5.7	5.1	2.8	0.6	4.3	7.2
Wetland	601.7	18,424.6	15,970.1	1,369.3	250.7	108.0	109.3	18.4	126.4	200.1
Open woodland	260.6	6,244.2	5,148.0	593.4	80.8	42.6	61.3	6.2	73.4	104.7
Disturbed forest	202.9	3,687.8	3,108.5	295.3	33.9	28.1	39.2	3.7	39.0	57.4
Grassland	720.2	7,565.7	6,665.0	487.8	82.9	41.8	43.6	7.6	49.3	79.6
Total	**8,225.7**	**120,975.8**	**102,327.7**	**9,894.5**	**1,317.6**	**847.5**	**1,103.3**	**121.0**	**1,190.1**	**1,765.3**

Source: Shvidenko et al 2011

According to Sohngen et al. (2005), the average carbon density of Russian forests is 36.2 (±5.5) t C per hectare in phytomass (Figure 4) and 162 (±37.6) t C in soils (top first meter). The estimates for phytomass is well within the range of various studies conducted in the late 1980s and 1990s *(cf. Figure 5)* (Sohngen et al., 2005).

Period of Estimation	Carbon Pool in Phytomass (BTCE)	Source
1993–2003	36.2 (±5.5)	Present study
Selected Other Studies		
1988 (Former Soviet Union)	68.7	Kolchugina and Vinson, 1993
1988	35.6	Isaev et al., 1995
1988–1992	32.9	Nilsson et al., 2000
1998	30.6	Pisarenko et al., 2000
1998	32.7	Filipchuk and Moiseev, 2003
1990–1999	N/A	Gytarsky et al., 2002
1993–1995	39.6	Kauppi, 2003

Figure 5. Comparison of Sohngen et al. (2005) to Selected Estimates from other studies of the Carbon Budget in Russia. (Adapted from Table 3.6 reported by Sohngen et al., 2005).

Nevertheless, it is recommended to use, via the Tier 2 approach in EX-ACT, the abovementioned variables, i.e. 36.2 tC.ha-1, thus 77 t dry matter considering a C content of 47%. It is noteworthy to mention that the IPCC default values for Boreal forest presents the same order of magnitude range, i.e. 23.5 tC.ha-1. In the absence of estimates for the other biomass compartments, e.g. belowground biomass, litter, dead wood and soil, estimates from Russian experts were considered *(cf. Appendix 1 for the list of participants)*. The soil carbon content in the top 0-30cm was assumed to be 64.8 tC.ha-1 (Moiseev & Filipchuk, 2003[10]). This represents 40% of the average value proposed for the top soil meter by Sohngen et al. (2005) and is close to the default value (68 tC.ha-1) proposed by the EX-ACT Tier 1 approach.

[10] Moiseev & Filipchuk, 2003. “Vklad lesov Rossii v uglerodnyy balans planety.[Contribution of the Russian Forest to Carbon Balance of the Planet].” Lesokhozyaystvennaya informatsiya, 2003, 1: 27–34. In Russian.

According to the Russian experts, the litter C content proposed by IPCC, i.e. Tier 1 approach in EX-ACT, was too elevated. Therefore, it was proposed to consider a mean value of 5 tC.ha-1. It was considered that the dead wood pool amounts 15 tC.ha-1. The belowground biomass was estimated using the default ratio of belowground biomass to aboveground biomass for the Boreal forest. Figure 6 shows the forest characteristics (second line, "Average Russian Forest") as compared to the Tier 1 approach. The module used in EX-ACT is forest degradation.

Type of Default forest/plantation proposed within the specified Climatic zone	Ecological Zone	Go to Map	Above-Ground Biomass tonnes dr	Above-Ground Biomass t C	Below-Ground Biomass tonnes dm	Below-Ground Biomass t C	Litter t C	Dead Wood tC	Soil C tC	Biomass Sub Total tC	Combustion % released of prefire dm	CH4 g.kg DM	N2O burnt
Natural	Forest1	Boreal coniferous forest	50	23,5	19,5	9,2	47	0	68	79,7	0,34	4,7	0,26
If you have your own data fill the information ->		Average Russian Forest	77,0	36,2	30	14	5	15	64,8	70,3	0,34	4,7	0,26
		Specific Vegetation 2	0	0	0	0	0	0	0	0,0	0,34	4,7	0,26
		Specific Vegetation 3	0	0	0	0	0	0	0	0,0	0,34	4,7	0,26
		Specific Vegetation 4	0	0	0	0	0	0	0	0,0	0,34	4,7	0,26

Figure 6: Average Russian forest characteristics, Tier 1 versus Tier 2 approach.

6. DATA ENTRY AND FIRST RESULTS

The following section demonstrates the results per activity, i.e. EX-ACT module, based upon the baseline assumptions from chapter 5.

6.1 Results from forest degradation module

The first module used is the forest degradation module. The assumptions for the evolution of forest degradation and the link to the evolution of fire occurrence have been entered as shown in the module *(cf. figure 7).* According to Moissev and Filipchuk (2001), ground fires amounted to 20% of the average carbon stock, thus the fire rate in EX-ACT was set to 20%. It was hypothesized that with the project, fire will occur every 5 years rather than each year for the same area. It is equivalent to a decrease of 80% of the area burnt annually.

Sequence Type	Vegetation Type concerned	Initial State		Final State Without Project					Final State WithProject				
		Degradation		Degradation		Fire			Degradation		Fire		
		Level	%	Level	%		Interval (year)	Rate (%)	Level	%		Interval (year)	Rate (%)
Veget.7	Average Russian Forest	Very low	10	Low	20	YES	1	20	Very low	10	YES	5	20
Veget.8	Specific Vegetation 2	Select level	0	Select level	0	NO	1	25	Select level	0	NO	1	25

Figure 7: Evolution of fire occurrence using the Forest degradation module in EX-ACT

It is possible to observe from figure 8 that 24,430,000Ha of degraded forest was entered in the tool. The management practices, i.e. in this case, burning practices are illustrated in figure 7. The C balance of the forest degradation activity results in a net sink of 1.2 billion T of CO_2eq, as a result of decreased fire. It is currently the highest emission reduction potential estimated on projects with the current tool, i.e. EX-ACT. It is equally linked with the large areas analysed.

GHG emissions														
Sequence Type	Degraded Forest Area (ha)					Biomass variation		Fire		Soil		Total Balance		Difference
	Start	Without Project		With Project		Without	With	Without	With	Without	With	Without	With	
	t0	End	Rate	End	Rate	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
Veget.7	*24,430,000*	*24,430,000*	*Linear*	*24,430,000*	*Linear*	629,885,205	0	421,516,974	94,252,243	-154,627,242	-469,569,844	896,774,937	-375,317,602	**-1,272,092,539**
Veget.8	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Veget.9	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Veget.10	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Degradation Total												**896,774,937**	**-375,317,602**	**-1,272,092,539**

Figure 8:Carbon balance results from the forest degradation activity.

6.2 Results from the deforestation module for preventive firebreaks

The project should mobilize around 200 forest fire brigades covering approximately 500km^2 (20x25km), supported by regional forest fire centres. The second type of protection is based on firebreaks[11] of 100m wide denuded areas (deforested) with a length planned of 15000km, i.e. 150,000ha deforested *(cf. table 2)*.

Table 2: Number of forest brigades and firebreaks estimated within the project

		km²/unit	Total coverage	
			km²	Ha
Number of brigades	200	500	100,000	10,000,000
Number of Regional Fire centers	5	3000	15,000	1,500,000
Area protected by firebreaks			60,000	6,000,000
Total area protected			175,000	17,500,000
% Forest area protected	Total forest area 244300 km2		72%	

[11] A **firebreak** (also called a **fireroad**, **fire line** or **fuel break**) is a gap in vegetation or other combustible material that acts as a barrier to slow or stop the progress of a bushfire or wildfire. A firebreak may occur naturally where there is a lack of vegetation or "fuel", such as a river, lake or canyon. Firebreaks may also be man-made, and many of these also serve as roads, such as a logging road.

Km of firebreaks	15,000	0.1	1500	150,000

It was assumed that with the project, 1,500,000Ha of forest would be deforested in order to build firebreaks. As observed in figure 9, the Tier 2 approach was used in this case, using precise data from the area. The deforestation activity results in a net source of approximately 42.3Mt of CO_2eq.

	Conversion details (Harvest wood product exported before the conversion, use of fire, final use after conversion)							Losses (positive value) and gain (negative value) per ha							
	Vegetation Type	**HWP before**		**Fire use**		**Final Use after**	Biomass (tC/ha)	Biomass		Soil			CH4	N2O	Total
Name		t DM/ha	t C exported	yes/no	% released	**deforestation**	1 yr after	t C	t CO2	k_{soil}	Delta C	tCO2/yr	kg	kg	tCO2 eq
Def.1	Please specify the vegetation		0	NO	0	Select Use after deforestation	0.0	0.0	**0.0**	0.00	0.0	**0.0**	0.0	0.0	**0.0**
Def.2	Please specify the vegetation		0	NO	0	Select Use after deforestation	0.0	0.0	**0.0**	0.00	0.0	**0.0**	0.0	0.0	**0.0**
Def.3	Please specify the vegetation		0	NO	0	Select Use after deforestation	0.0	0.0	**0.0**	0.00	0.0	**0.0**	0.0	0.0	**0.0**
Def.4	Please specify the vegetation		0	NO	0	Select Use after deforestation	0.0	0.0	**0.0**	0.00	0.0	**0.0**	0.0	0.0	**0.0**
Def.5	Please specify the vegetation		0	NO	0	Select Use after deforestation	0.0	0.0	**0.0**	0.00	0.0	**0.0**	0.0	0.0	**0.0**
Def.6	Please specify the vegetation		0	NO	0	Select Use after deforestation	0.0	0.0	**0.0**	0.00	0.0	**0.0**	0.0	0.0	**0.0**
Def.7	Average Russian Forest		0	NO	0	Set aside	5.0	70.29	**257.7**	0.82	11.7	**2.1**	0.0	0.0	**0.0**
Def.8	Specific Vegetation 2		0	NO	0	Select Use after deforestation	0.0	0.00	**0.0**	0.00	0.0	**0.0**	0.0	0.0	**0.0**
Def.9	Specific Vegetation 3		0	NO	0	Select Use after deforestation	0.0	0.00	**0.0**	0.00	0.0	**0.0**	0.0	0.0	**0.0**
Def.10	Specific Vegetation 4		0	NO	0	Select Use after deforestation	0.0	1.00	**3.7**	0.00	0.0	**0.0**	0.0	0.0	**0.0**

GHG emissions																	
Vegetation Ty	**Forested Area (ha)**					**Area deforested (ha)**		Biomass loss		Biomass gain (1yr after)		Soil (baseline)		Fire		**Total Balance**	
	Start	**Without Project**		**With Project**		Without	With	Without	With	Without	With	Without	With	Without	With	Without	With
	t0	End	Rate	End	Rate			tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
Def.1	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	0	0	0	0
Def.2	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	0	0	0	0
Def.3	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	0	0	0	0
Def.4	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	0	0	0	0
Def.5	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	0	0	0	0
Def.6	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	0	0	0	0
Def.7	*150000*	*150000*	*Linear*	*0*	*Immediate*	0	150000	0	38659500	0	-2750000	0	6415200	0	0	0	42324700
Def.8	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	0	0	0	0
Def.9	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	0	0	0	0
Def.10	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	0	0	0	0

Deforestation Total	**0**	**42324700**

Figure 9: Carbon balance results from the deforestation activity.

6.3 Data entry and results in the other investments module

Mobilized fire control means were not yet fully specified within the pre design work at a programme identification level. Therefore the expert team established certain assumptions to design the fire control means in terms of fire control brigades and fire breaks. A fire brigade is a team of fire fighters trained and equipped, provided with mobility means in order to ensure fire control and prevention on a forest area of 200 to 800 square km (km^2).

The aggregate fuel and kerosene consumption of the project on 5 years was estimated at 8,900m^3. Accounting consumption on the whole period of 25 years (20 years of capitalisation), it becomes (8900*5)=44,500 m^3. Aggregate building areas are entered below, corresponding to 21,500 m^2. *(Cf. figure 10).* The carbon balance results in a net source of 32,806 T CO_2eq.

Released GHG associated with Fuel consumption (agricultural or forestry machinery, generators...)

GHG emissions associated with inputs transportation is not included here! But in "Inputs"

OPTION 1 (Based on Total consumption over the whole duration of the project)

Total Liquid Fuel Consumption (m3)	Gasoil/Diesel	Gasoline	Associated tCO2eq
Without Project	0	0	0
With Project	44500	0	117161

Released GHG associated with building of infrastructure

Type of construction or infrastructure	Default value	Specific	Default	surface (m2)		**Emission (t CO2eq)**	
	t CO2 /m2	Value	Factor	Without	With	Without	With
Housing (concrete)	0.436		YES		21500	0.0	9374.0
Please select	0.000		YES			0.0	0.0
Please select	0.000		YES			0.0	0.0
Please select	0.000		YES			0.0	0.0
Please select	0.000		YES			0.0	0.0
Please select	0.000		YES			0.0	0.0
Please select	0.000		YES			0.0	0.0

Subtotal	0.0	9374.0	*Difference*	*9374.0*

SUB-TOTAL FOR INVESTMENT	**Without**	**0**	**With**	**32806**	**Difference**	**32806**

Figure 10: The carbon balance result for the investment module.

6.4 Final Results of the carbon balance

The project results is a net sink of approximately 1.23 billion tons of CO_2eq, which also presents the additionally of the project as compared to the baseline *(cf. figure 11)*. The results per Ha over 25 years is -50 tons and per Ha per year 26.5 t of C is sequestered during the implementation phase and 23.5 t of C during the capitalization phase. This amount corresponds to avoided losses of biomass (594 Mt CO_2) and soil organic matter (308 Mt CO_2) followed by the avoided N_2O and CH_4 emissions as a result of burning (147 and 180 Mt CO_2 equivalents). It is possible to observe from figure 11 that the proposed improvements with the project scenario concerning the forest degradation activities, i.e. reduced burning/fires, compensate for the deforestation activity, corresponding to the settlement of firebreaks. The improvements in forest degradation also compensates for the necessary investments. In that sense, the decreased fires shows the importance of finding a balance between climate change mitigation and the incorporation of preventive measures, i.e. deforestation/firebreaks, as well as capacity building, i.e. investment if infrastructure, vehicles and human capital. This type of analysis can also be linked to an increased resilience of eco-systems as a result of gain in the phytomass and soil.

Project Summary	
Name	Forest Fire Response Project
Continent	Asia (Continental)
Climate	Boreal Moist
Dominante Soil	HAC Soils

Area (Initial state in ha)		
Forest/Plantation		24580000
Cropland	Annual	0
	Perennial	0
	Rice	0
Grassland		0
Other Land	Degraded	0
	Other	0
Organic soils/peatlands		0

Duration of the Project (years)	
Implementatior	5
Capitalisation	20
Total	25
Total Area	
Mineral soils	24580000
Organic soils	0
Total Area	**24580000**

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq		CO2 Biomass	CO2 Soil	N2O	CH4	Per phase of the project: Implement.	Capital.
Deforestation	**42324700**	**this is a source**	35909500	6415200	0	0	42324700	0
Forest Degradation	**-1272092539**	**this is a sink**	-629885205	-314942602	-147113984	-180150747	-694910585	-577181954
Afforestation and Reforestation	**0**		0	0	0	0	0	0
Non Forest Land Use Change	**0**		0	0	0	0	0	0
Agriculture								
Annual Crops	**0**		0	0	0	0	0	0
Agroforestry/Perennial Crops	**0**		0	0	0	0	0	0
Irrigated Rice	**0**		0	0	0	0	0	0
Grassland	**0**		0	0	0	0	0	0
Organic soils and peatlands	**0**		--	0	0	0	0	0
Other GHG Emissions			CO2 (other)					
Livestock	**0**		---		0	0	0	0
Inputs	**0**		0		0	---	0	0
Other Investment	**126535**	**this is a source**	126535		---	---	32806	93729
Final Balance	**-1,229,641,304**	**It is a sink**	**-593,849,170**	**-308,527,402**	**-147,113,984**	**-180,150,747**	**-652,553,079**	**-577,088,225**
In % of Emission without project:	**-137.1%**							
Result per ha	**-50.0**		**-24.2**	**-12.6**	**-6.0**	**-7.3**	**-26.5**	**-23.5**

Figure 11: The total carbon balance for the FERP.

6.5 Uncertainty of results

The level of uncertainty of the appraisal is relatively low, estimated at 19%. It is essentially due to the use of Tier 2 data in the analysis and the focus on forestry modules for which, IPCC considers lower levels of uncertainty *(cf. figure 12)*. The ** illustrates an uncertainty level of 20% and the * shows an uncertainty level of 10%. This can be found in the carbon balance module of EX-ACT beneath the balance results table.

Indication of the level of uncertainty expected

Components of the Project	Main approach used	CO2		N2O	CH4	CO2		N2O	CH4
		Biomass	Soil			Biomass	Soil		
Deforestation	Tier 2	**	**	*	*	7181900	1283040	0	0
Forest Degradation	Tier 2	**	**	*	*	125,977,041	62,988,520	14,711,398	18,015,075
Afforestation and Reforestation	Tier 1	***	****	**	**	0	0	0	0
Non Forest Land Use Change	Tier 1	***	****	**	**	0	0	0	0
Agriculture									
Annual Crops	Tier 1	**	****	**	**	0	0	0	0
Agroforestry/Perennial Crops	Tier 1	****	****	**	**	0	0	0	0
Rice	Tier 1	**	****	**	**	0	0	0	0
Grassland	Tier 1	**	****	**	**	0	0	0	0
Organic soils and peatlands	Tier 1	--	****	****	****	--	0	0	0
Other GHG Emissions		CO2 (other)				CO2 (other)			
Livestock	Tier 2	---		**	**	---		0	0
Inputs	Tier 1	***		***	---	0		0	---
Other Investments	Tier 1	***		---	---	10,826		---	---

Problem of permanency may arise	
Total uncertainty	230,167,801
Global level of uncertainty (%)	19

Figure 12: Level of uncertainty from the EX-ACT tool.

7. ELEMENTS OF ECONOMIC ANALYSIS

In this paper, the present analysis is limited to GHG emissions, which is a project co-benefit among other indicators, such as protection of local population, reduction of air pollution, increased supply of forest wood, reduced human health impact of fire clouds and dust and reduced damages of fires on infrastructure and different economic activities. It is noteworthy to mention that the economic analysis only takes into account the C benefits and is based on estimated costs from what was discussed during the workshop that took place together with Russian experts *(cf. Appendix 1)*.

As specified in table 3, regarding vehicles, staff and other mobilized means, e.g. fuel and kerosene, and in terms of budget, such a programme is tentatively designed as follows, based on current similar projects at local level. With 5000 tons of fuel consumption for the brigades, i.e. 5000 litres per year during 5 years, 2400 m3 of kerosene, i.e. 1000 hours of plane per year per regional centre, and 1500 m3 of fuel for bulldozers mobilized in fire breaks, the total fuel consumption is estimated at 8900 m3 over five years. Table 3 shows the related costs with regards to the fire brigades and the firebreaks.

Table 3: Project investment costs

	Number /Unit	Total number	Unit cost USD	Budget/year USD	Total budget USD
Fire control direct costs					
Number of motorbikes	2	400	1000		**400,000**
Number of vehicles 4x4	1	200	20000		**4,000,000**
Number of staff in brigades	2	400	7200	2,880,000	**14,400,000**
Number of staff in Regional centers	10	50	7200	360,000	**1,800,000**
Number of volunteers/ brigade	5	1000	1000	1,000,000	**5,000,000**
Number of fire fighting equipment	8	1600	1000		**1,600,000**
Area of brigade office (m2)	100	20,000	500		**10,000,000**
Regional fire centers (m2)	300	1500	500		**750,000**
Fuel budget per brig (liter/ year)	5000	1,000,000	1	1,000,000	**5,000,000**
Kerosene per regional center (1000 hours)	96,000	480,000	1	480,000	**2,400,000**
Bulldozer work for fire breaks (hrs/km)	10	150,000	30	4,500,000	**22,500,000**
Bulldozer fuel consumption		*1,500,000*			
Communication -training costs					**5,000,000**
Other project costs					**10,000,000**
Maintenance and operational costs					**8,285,000**
TOTAL (Million USD)					**91.14**

Based on an aggregate project cost (5 years) and a post project cost (20 years) of USD 153 million[12] and a carbon balance of -1.23 billion tons of CO_2 emissions, the public cost per ton of CO_2 emissions reduction, results in USD 0.12 per ton CO_2 (not considering the monitoring reporting and verification (MRV) cost). The Net Present Value (NPV) is only based on a carbon price as the harvested wood data is unavailable. The NPV of the public cost per ton of CO_2eq is at 0.08 USD, which would position it as a relatively cheap GHG emissions reduction. Using project budget expenses and valuing CO_2 emission reductions at different opportunity prices (USD 6, USD 8 or USD 10), the following gross returns have been derived. They show a high return of carbon public value generated *(cf. table 4 and 5)*.

[12] Project cost 91 million US$ on 5 years + operational costs of the protection system on 20 years

Table 4: Simulated economic gross returns of the project

	Economic gross returns	
	At USD 6 /TCO_2eq	At USD 8 /TCO_xeq
Gross value of GHG reductions (million US$)	7378	9837
Gross return per US$ invested	$ 48.22	$ 64.29
Gross return per ha of forest protected US$/ha	$ 300.16	$ 400.21
Gross return per year (US$ million)	295	393

Table 5: Simulated economic NPV of the project

	Economic NPV	
Discount rate 10%	At USD 6 /TCO_2eq	At USD 10 /TCO_2eq
NPV of project (million US$)	3169	4280
NPV per US$ invested (profitability index)	$ 20.71	$27.82
NPV per Ha	$ 128.93	$ 174.13
NPV per Ton CO2eq	2.58	3.48

Within the objective to select projects that have the potential to maximize the total NPV of the capital budget, the profitability index (PI) is used to compare projects regarding the return on capital. Using the PI approach permits to maximize the increment in wealth per dollar invested. Within this project, the profitability index, i.e. NPV per dollar invested, underlines the high relevance of public investments for fire protection. It also illustrates the relevance of fire protection for private forest investments and opens a window for business opportunities in case of access to carbon markets.

8. CONCLUSIONS

The paper describes the ex-ante carbon-balance analysis performed in Moscow, with project designers. It consolidates different assumptions to figure out the preliminary results of the carbon balance for the Forestry Emergency Response Project. It proposes a scenario of implementation with fire protection brigades and estimates the economic relevance of such investment with regards to GHG emissions reduction. The results confirm the large potential of GHG emissions reduction provided by wide fire protection public programmes, placing the project within a high return on public investments.

9. LINKS TO OTHER EASYPOL MATERIALS

- EX-ACT technical guidelines
- EX-ACT policy briefs

10. REFERENCES

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APPENDIX 1: LIST OF EXPERTS

Name	**Title/Role**
Anna Eremonko	World Bank, Moscow
Elena Kulikova	WWF, Russia
Olga Khlebinskaya	International Finance Corporation
Olga Khoreva	Russian Academy of Public Administration
Vladimir Berdin Qun Li	World Bank, Moscow
Andrew Mitchell	Forestry Specialist, World Bank
Ron Hoffer	World Bank Environment for Europe and Central Asia
Professor Boris N. Moiseev	Soil Specialist Director of the Forest Institute of Agricultural Sciences