

WP5 Forest Operations

Task 5.2 Perspectives of Forest Operations

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Introduction

With regard to climate and demographic changes and the conservation of resources, sustainable forest management is required, particularly in better understanding the impacts from different harvesting systems. Beside others, forest operations are characterized by the indicators CO₂-emissions, work productivity, job provision, wood supply costs and fuel consumption.

Improvements of individual harvestings systems are (partly) known, e.g. replacing gasoline-powered chainsaws by electric-powered chainsaws. However, their impact and contribution on regional level is widely unknown.

Methodology

The three major harvesting systems were chosen for the simulation: **Harvester-Forwarder (HFW)**, **Chainsaw-Skidder (CSK)** and **Chainsaw-Cable Yarder (CCY)**.

An extensive literature research was carried out and data from national inventories and databases were consulted to assign values to the five indicators for each harvesting system.

With the help of a terrain model and a forest map, the percentage distribution of the slope classes within the forest areas was calculated. The slope classes followed common access conditions (**Tab 1**). For each slope class, a harvest combination was allocated. For class 30 – 60% all three harvesting systems were possible and therefore taken into account.

Tab 1: Description of harvesting systems for different slope conditions

Slope class	Description	Harvesting system
< 30%	Driving with forest machines is possible without restrictions	HFW – fully mechanized operations
30 – 60%	Driving with forest machines is limited and supportive cable might be needed in areas of > 45% or skidding operations in steep areas need to be applied	100% HFW – fully mechanized operations 100% CSK – semi-mechanized operations with motor-manual tree felling and processing 50% HFW + 50% CSK -- both systems are applied in the same ratio
>60%	Driving with forest machines is impossible and log extraction with cable yarder is the only way	CCY -- semi-mechanized operations with motor-manual tree felling and processing

For the combination of the BEST harvesting system, all indicator values were modelled and calculated in line with Bont et al 2021. Results were compared against the status quo of these regions (Engler et al. 2024). The indicators were calculated for all four Case Study Regions (CSR) and a BEST harvesting system was selected.

By now, the BEST harvesting system refers to the current condition and management of forests in the CSRs. The next step is to model the impact from harvesting systems for future forests (linked to WP1 – 4).

Conclusions

HFW, which represents the harvesting system with the highest degree of mechanization, is in most cases the BEST harvesting system with regard to all indicators. This applies to all CSR. The high productivity of the HFW compensates high costs of the systems.

This might change with increasing shares of deciduous tree species, which was yet not taken into account. Furthermore, regulation on skid road distances might lead to an increasing importance of CSK operations.

Results

The calculations for the CSR Catalonia are presented in example of all CSR.

Harvested Wood in 2021 (m ³)			Slope Class distribution			Indicators and its value for Catalonia					
HFW (Harvester-Forwarder)	248.168	30,00%	< 30 %	61,68%	HFW	6,95	11,80	4,51	10,54	1,10	
CSK (Chainsaw-Skidder)	579.058	70,00%	30 - < 60 %	31,95%	CSK	7,71	3,33	15,96	24,90	0,85	
CCY (Chainsaw-Cable Yarder)	0	0,00%	> 60 %	6,37%	CCY	1,75	4,65	11,44	14,95	5,10	

Amount of harvested wood and its percentage distribution considering the slope class

Harvesting Method	100% CSK		100% HFW		50% CSK/50% HFW	
	Amount of wood (m ³)	Percentage share (%)	Amount of wood (m ³)	Percentage share (%)	Amount of wood (m ³)	Percentage share (%)
HFW	510.232,5	61,68%	774.525,1	93,63%	642.378,8	77,65%
CSK	264.292,6	31,95%	/	/	132.146,3	15,97%
CCY	52.700,9	6,37%	52.700,9	6,37%	52.700,9	6,37%

Indicators and harvested wood multiplied to get the individual value of the three combinations

	CO ₂ -Emissions (kg CO ₂ /m ³)	Productivity (m ³ /smh)	Jobs (PM/10000m ³)	Costs (€/m ³)	Fuel consumption (l/m ³)
Indicators Status quo					
HFW	1.724.766,21	2.928.380,04	111,87	2.614.979,56	272.984,58
CSK	4.466.203,51	1.929.872,30	924,18	14.418.549,18	492.199,47
CCY	0,00	0,00	0,00	0,00	0,00
Total	6.190.969,72	4.858.252,34	1.036,05	17.033.528,74	765.184,05
Indicators 100% CSK					
HFW	3.546.116,21	6.020.744,06	230,00	5.376.393,24	561.255,80
CSK	2.038.455,77	880.828,50	421,81	6.580.885,68	224.648,71
CCY	92.410,95	245.058,98	60,28	787.877,78	268.774,36
Total	5.676.982,92	7.146.631,53	712,10	12.745.156,70	1.054.678,87
Indicators 100% HFW					
HFW	5.382.949,76	9.139.396,71	349,14	8.161.282,10	851.977,66
CSK	#WERT!	#WERT!	#WERT!	#WERT!	#WERT!
CCY	92.410,95	245.058,98	60,28	787.877,78	268.774,36
Total	3.638.527,16	6.265.803,04	290,28	6.164.271,02	830.030,16
Indicators 50% CSK/50% HFW					
HFW	4.464.532,98	7.580.070,39	289,57	6.768.837,67	706.616,73
CSK	1.019.227,88	440.414,25	210,91	3.290.442,84	112.324,35
CCY	92.410,95	245.058,98	60,28	787.877,78	268.774,36
Total	5.576.171,82	8.265.543,61	560,76	10.847.158,29	1.087.715,44

Amendment of indicators from status quo to best practice

	CO ₂ -Emissions (kg CO ₂ /m ³)	Productivity (m ³ /smh)	Jobs (PM/10000m ³)	Costs (€/m ³)	Fuel consumption (l/m ³)
Amendment of indicators from status quo to best practice					
HFW	105,60%	105,60%	105,60%	105,60%	105,60%
CSK	-54,36%	-54,36%	-54,36%	-54,36%	-54,36%
CCY	/	/	/	/	/
Total	-8,30%	47,10%	-31,27%	-25,18%	37,83%
Amendment of indicators from status quo to best practice					
HFW	212,10%	212,10%	212,10%	212,10%	212,10%
CSK	/	/	/	/	/
CCY	/	/	/	/	/
Total	-41,23%	28,97%	-71,98%	-63,81%	8,47%
Amendment of indicators from status quo to best practice					
HFW	158,85%	158,85%	158,85%	158,85%	158,85%
CSK	-77,18%	-77,18%	-77,18%	-77,18%	-77,18%
CCY	/	/	/	/	/
Total	-9,93%	70,13%	-45,88%	-36,32%	42,15%

Indicators of status quo and their change depending on the harvest combination.

Harvesting Combination	CO ₂ -Emissions		Amendment	
	Sum t_CO ₂ eq	Sum t_CO ₂ eq	Delta t_CO ₂ eq	Delta %
HFW + CSK + CCY	6.190.969,7	5.676.982,9	-513.986,8	-8,3%
HFW + HFW + CCY	6.190.969,7	3.638.527,2	-2.552.442,6	-41,2%
HFW + 1/2 HFW + 1/2 CSK + CCY	6.190.969,7	5.576.171,8	-614.797,9	-9,9%
Jobs				
Harvesting Combination	Jobs		Amendment	
	Sum PM/10.000m ³	Sum PM/10.000m ³	Delta PM/10.000m ³	Delta %
HFW + CSK + CCY	1.036,1	712,1	-324,0	-31,3%
HFW + HFW + CCY	1.036,1	290,3	-745,8	-72,0%
HFW + 1/2 HFW + 1/2 CSK + CCY	1.036,1	560,8	-475,3	-45,9%
Costs				
Harvesting Combination	Cost Sum		Amendment	
	Sum €/m ³	Sum €/m ³	Delta €/m ³	Delta %
HFW + CSK + CCY	17.033.528,7	12.745.156,7	-4.288.372,0	-25,2%
HFW + HFW + CCY	17.033.528,7	6.164.271,0	-10.869.257,7	-63,8%
HFW + 1/2 HFW + 1/2 CSK + CCY	17.033.528,7	10.847.158,3	-6.186.370,4	-36,3%
Productivity				
Harvesting Combination	Productivity		Amendment	
	Sum m ³ /shm	Sum m ³ /shm	Delta m ³ /shm	Delta %
HFW + CSK + CCY	4.858.252,3	7.146.631,5	2.288.379,2	47,1%
HFW + HFW + CCY	4.858.252,3	6.265.803,0	1.407.550,7	29,0%
HFW + 1/2 HFW + 1/2 CSK + CCY	4.858.252,3	8.265.543,6	3.407.291,3	70,1%
Fuel Consumption				
Harvesting Combination	Fuel Consumption		Amendment	
	Sum l/m ³	Sum l/m ³	Delta l/m ³	Delta %
HFW + CSK + CCY	765.184,1	1.054.678,9	289.494,8	37,8%
HFW + HFW + CCY	765.184,1	830.030,2	64.846,1	8,5%
HFW + 1/2 HFW + 1/2 CSK + CCY	765.184,1	1.087.715,4	322.531,4	42,2%

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