EFFORTE –

'Efficient forestry by precision planning and management for sustainable environment and cost-competitive bio-based industry'

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Coordinator: Natural Resources Institute Finland (Luke).

P	Prototype	
D	Demonstrator	
O	Other	

Validation and analyses of expected impacts

Expected impacts of EFFORTE outcomes

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1. EFFORTE project objectives

EFFORTE is a research and innovation project providing the European forestry sector with new knowledge and knowhow that will significantly improve the possibilities of forest enterprises to assemble and adopt novel technologies and procedures.

The project aims at enhancing the efficiency of silviculture and harvesting operations; increasing wood mobilization and annual forest growth; increasing forest operations' output while minimizing environmental impacts; and reducing fuel consumption in the forest harvesting process by at least 15%.

The project is based on three key elements of technology and knowhow:

1) Basic understanding of fundamentals of **soil mechanics and terrain trafficability** is a crucial starting point to avoid soil disturbances, accelerate machine mobility and assess persistence of soil compaction and rutting. The key findings and recommendations of trafficability related to EFFORTE can immediately be adapted in all European countries.

2) Due to decreasing Cost-competitiveness of manual work and maturity of technology it is now perfect time to realize the potential of **mechanization in silvicultural operations**. EFFORTE pursues for higher productivity and efficiency in silvicultural operations such as tree planting and young stand cleaning operations.

3) 'Big Data' (geospatial as well as data from forestry processes and common information e.g. weather data) provides a huge opportunity to increase the efficiency of forest operations. In addition it adds new possibilities to connect knowledge of basic conditions (e.g. trafficabillity), efficient silviculture and harvesting actions with demand and expectations from forest industries and the society. Accurate spatial information makes it possible for forestry to move from classic stand-wise management to precision forestry, i.e. micro stand level, grid cell level or tree-by-tree management. EFFORTE aims at achieving substantial influence to the **implementation and improved use of Big Data within Forestry** and through this increase Cost-efficiency and boost new business opportunities to small and medium size enterprises (SME) in the bioeconomy.

EFFORTE researchers will develop and pilot precision forestry applications that, according to the industrial project partners, show the greatest potential for getting implemented immediately after the project.

2. Introduction

EFFORTE has aimed at matching expected impacts of the call which in the original call text was defined as:

- Improving the efficiency in silviculture and harvesting operations
- Improving accessibility to wood resources leading to a significant increase in productivity in forest operations over a representative period of time: a 1% annual increase in forest growth, projected on a 20 year period, would yield 22% increase with respect to the original volume, roughly equivalent to 2 years of forest growth gained
- Increasing forest operations output while reducing negative environmental impacts: reducing soil disturbance, more efficiently performed thinning and/or more efficiently extracted logging residues
- Reducing fuel consumption in the forest harvesting process by at least 15%

In order assess how well the expected impacts of the call had been achieved; a survey was conducted among the industrial partners of the consortium. The aforementioned impacts were simplified to the following form:

- The outcomes of the project will improve efficiency of silviculture operations
- The outcomes of the project will increase forest growth
- The outcomes of the project will increase productivity of harvesting operations
- The outcomes of the project will reduce negative environmental impacts

In addition to the above listed impacts two other impacts;

- The outcomes of the project will increase value of the forest products
- The project will have impact on the socio-economic aspect on forestry

were regarded as similarly important targets since they were strongly addressed in the call; text.

The aim of the survey was first and foremost assesses how well the project has achieved the expected impacts and targets related to dissemination and exploitation of the new knowledge, methods and tools.

3. Material and method of the project evaluation

The contents of the survey were structured by representatives of all research organisations of the project; Luke, Metsäteho, Skogforsk, SLU and FCBA. The survey was introduced in the final seminar and distributed by e-mail. The survey was executed during 20.6.-5.7.2019. The questionnaire was sent to all industrial project partners of the project. In total, responses from the 17 companies were obtained (Table 1).

Table 1. The list of industrial that participated in the survey by countries.

Finland	Scotland	Sweden	France
Metsä Group Oyj	James Jones & Sons Ltd	SCA Skog AB	Forets et Bois de l'Est (FBE)
UPM Oyj	Woodilee Consultancy Ltd	Holmen aktivbolag	Office National des Forets (ONF)
Stora Enso Oyj		Sveaskog Förvaltning AB	sarl Ste d'Exploitation Forestière de l'Est (SEFE)
Metsäteho Oy		Södra Skogägarna	Comptoir des Bois de Brive (CBB)
Arbonaut Oy		Stora Enso Skog AB	
		Creative Optimization	

The questionnaire was divided to three main sections; a) general evaluation, b) detailed assessment of the impact of each outcome and c) satisfaction of the Efforte-project. The general evaluation consisted of a set of questions in the themes of a) participation, b) outcomes, c) dissemination and d) impacts.

In the general evaluation section outcomes, dissemination and impacts were assessed with simple claims linked with the Likert-scale five options' answers (e.g. The outcomes of the project has been reported at suitable manner, efficiency and magnitude / 1 strongly disagree, 2 disagree, 3 undecided, 4 agree, 5 strongly agree).

In addition to general evaluation, each impact of each outcome of the project was assessed separately. With outcome we refer to models, tools or knowledge that was developed and tested during the project. Each outcome was assessed in the context of the most important impacts, i.e. does the outcome a) increase of efficiency of silvicultural operations, b) Increase forest productivity (i.e forest growth), c) Increase of productivity of harvesting operations and d) reducing negative environmental impacts.

The connection between outcome and impacts had been pre-assessed by the researchers by the following category: xxx = the outcome has significant bearing with the impact, xx = the outcome has clear potential to significantly affect on the impact, or x = there is only minor bearing between the outcome and impact. Respondents then had to evaluate how well researchers' assessment corresponded to their own opinion by the scale of three options (I mostly agree, I partly agree and I disagree).

In addition, for each project outcome, respondents had to assess the possibility to adopt the result into practice, i.e. how easily the results can be utilized in operative use, for example, to be integrated into a forest information system.

4. Results of the survey

General evaluation

Roughly 200 people have been participating in the Efforte-activities and events, while information of project's outcomes has been forwarded to more than 500 persons among the companies (Figure 1). Dissemination efficiency of the project outcomes was highest in Sweden and France.
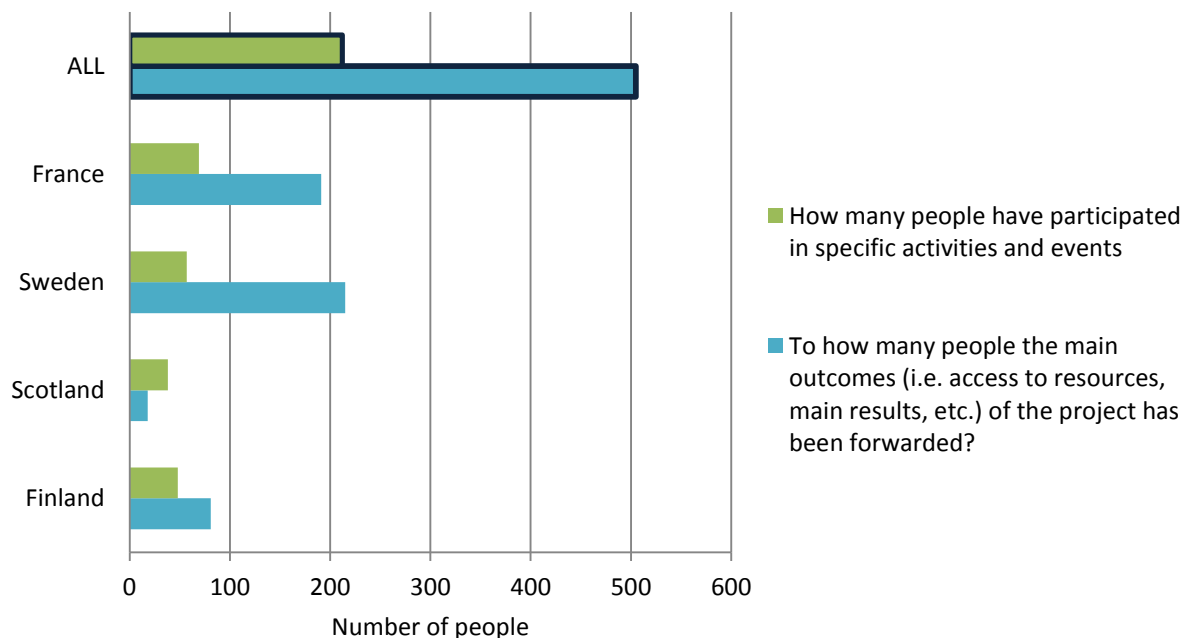

Figure 1. Participation and dissemination efficiency of Efforte-project among project's industrial partners. Sums by participating countries.

Dissemination methods and the success of dissemination to the target groups, training and workshops have been successful and outcomes of the project have been reported at a suitable manner, efficiency and magnitude (Figure 2). However, some variation in country and respondent specific answers were seen. The value of the produced videos and films in Efforte got lowest scores, mostly because rather limited number of videos was produced.
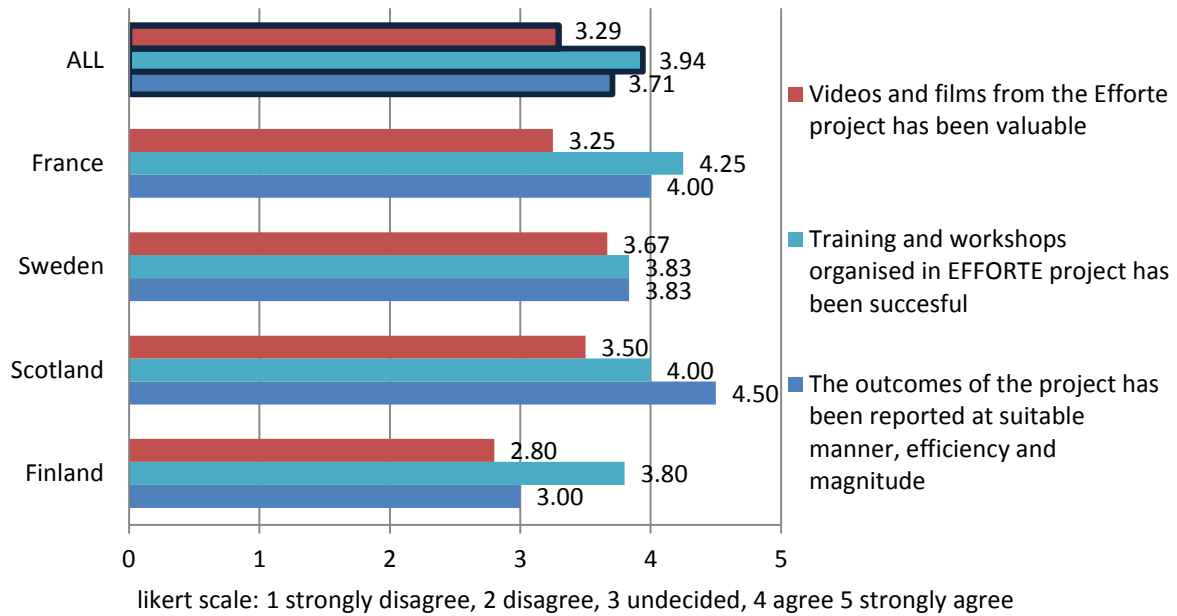
Figure 2. Success in dissemination of Efforte-outcomes. Averages by countries and total.

According to survey, Efforte has succeeded in disseminating new skills and knowledge to practitioners. Many companies reported that they are planning to chance their practices or behaviour as a result of the project (Figure 3).

In assessing the most important and beneficial themes from the presented list, themes of terrain trafficability, planning of forest operations and soil compaction and rutting were the most beneficial themes amongst other (Figure 4). Small country-vice differences were seen while determining the most beneficial themes (i.e. the first priority theme from all); Finland stressed more terrain trafficability, Sweden more planning of forest operations and France soil compaction and rutting (Figure 4).
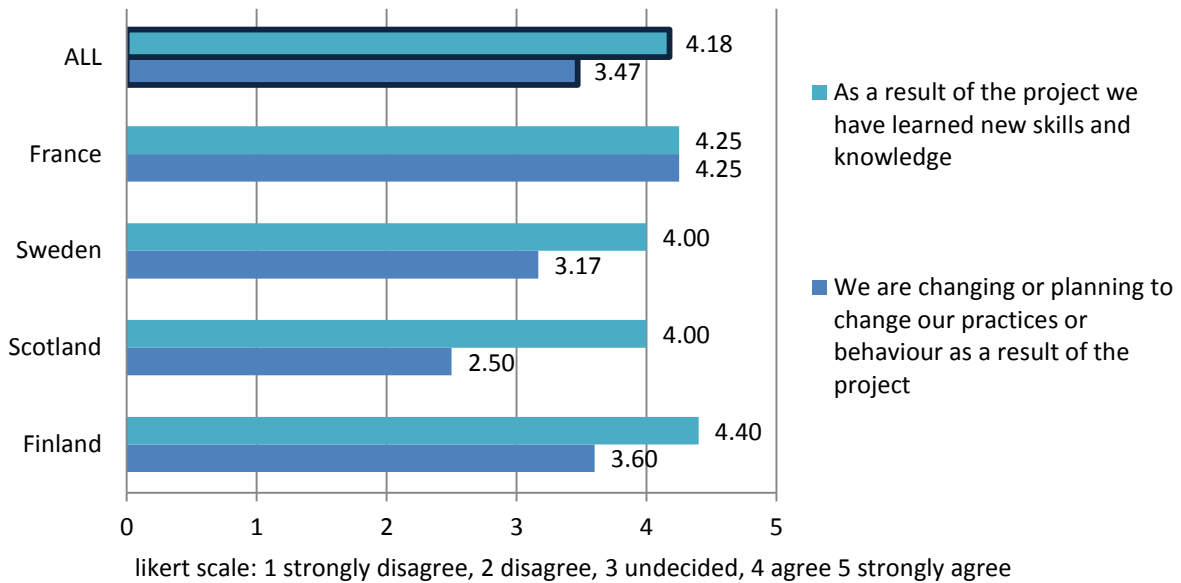
Figure 3. Adopting new skills and knowledge and chancing practices as a result of Efforte-project. Averages by countries.
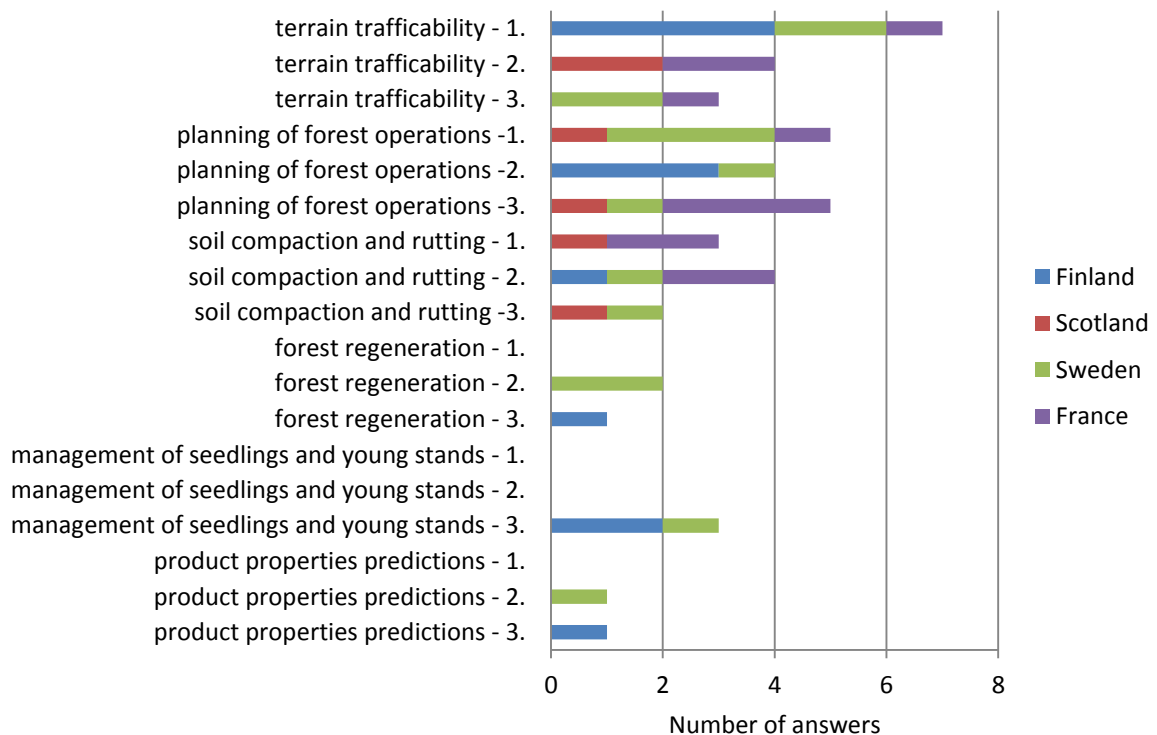

Figure 4. Most important and beneficial themes in Efforte according to the respondents (1. - most important, 2. - second important and 3. - third important). Sums by countries.

To sum the responds of all countries on presented claims of the project impacts, respondents agreed on that "the outcomes of the project will increase the productivity of harvesting operations" and "the outcomes of the project will reduce negative environmental impacts". These two claims got most agreeable responds in all countries, thus consensus was easy to notice among countries. In other claims results were between "undecided" and "agree" amongst all (Figure 5).
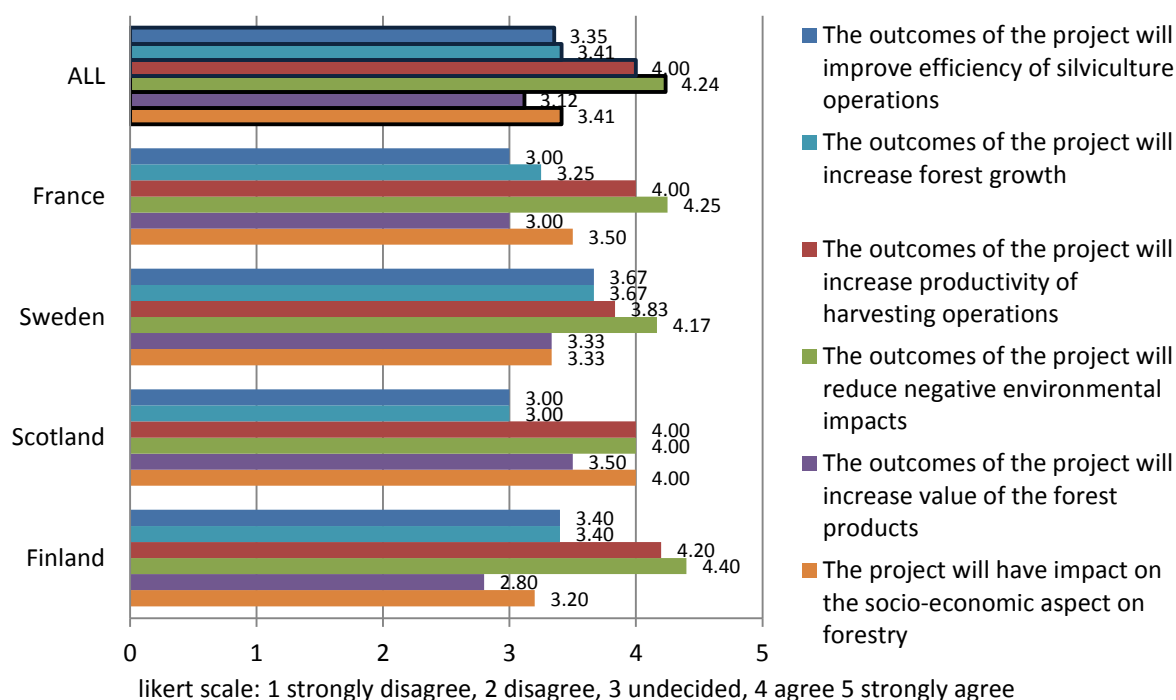

likert scale: 1 strongly disagree, 2 disagree, 3 undecided, 4 agree 5 strongly agree

Figure 5. Responds for the claims of the impacts of Efforte-projects. Averages by countries and in total.

Impact of each outcome

In the theme of soil mechanics and trafficability (WP1) respondents were mostly agreeing on researchers' assessments (Table 2). There were only a few disagreements in total. In The efficient silviculture theme (WP2), responds were divided evenly to the "mostly agree" and "partly agree", however only two disagreements were resulted. In big data applications (WP3), "mostly agree" respond was a dominating result. Highest responds in possibility to adopt the result into practice were obtained by the following methods, models and tools: Dynamic soil water map (12 responds), Recommendations on how to avoid soil disturbances (12), Depth to water (DTW) maps (10), Static trafficability map (10), Optimal routing: Bestway and Ajourakone (10), Modelling relationship between soil moisture and strength (9), Models predicting rutting and compaction (9), Long term effects of forest trafficking (9) and, Decision support for precision forestry regeneration (9).

Table 2. The outcomes versus impacts. Country specific responds to each outcome and impact (researchers' assessment). Numbers are summed responses.

Outcome of the project	Increase of efficiency of silvicultural operations	Increases forest productivity (i.e forest growth)	Increase of productivity of harvesting operations	Reducing negative environmental impacts	MA Fin	MA Sco	MA Swe	MA Fra	MA All	PA Fin	PA Sco	PA Swe	PA Fra	PA All	D Fin	D Sco	D Swe	D Fra	D All	NO Fin	NO Sco	NO Swe	NO Fra	NO All	PO Fin	PO Sco	PO Swe	PO Fra	PO All
Soil mechanics and trafficability																													
Models predicting moisture content on permanent logging trails			xx	xx	3	1	3	2	9	1		1	1	3						1	1	2	1	5	3	1	3	1	8
Modelling relationship between soil moisture and strength			xx	xx	4	2	3	3	12	1		1	1	3								2		2	4	1	2	2	9
Models predicting rutting and compaction			xxx	xxx	5	1	3	2	11		1	1	2	4								2		2	4	1	3	1	9
Long term effects of forest trafficking		xx			2	1	2	2	7	3	1	1	2	7								2		2	3	1	3	2	9
Recommendations on how to avoid soil disturbances		x	xx	xxx	3	1	3	2	9	1		2	2	5						1	1	1		3	4	1	5	2	12
Efficient silviculture																													
Increased knowledge about continuous site preparation and mechanized planting	xx	xx		x	2		3	1	6	2		3		5						1	1		3	5	2		4		6
Increased knowledge about silvicultural efficiency of uprooting	xx	x			2		3	1	6	3		3		6						1	1		3	5	2		3		5
Feasibility of biocontrol of sprouting with C. purpureum in practical mechanized PCT operation	xx	x			1		2		3	3		1	1	5		1			1	1	1	2	3	7					
Increased knowledge about new technique and methods for systematic biomass thinning	x		xx		4		2	1	7	1		1	1	3		1			1		1	2	2	5	2		2		4
Decision making aid for selection of regeneration chain / comparison of different regeneration and young stand management regimes	xx	x		x	2		2		4	2		3	2	7							1	1	2	4	3		4		7
Decision support for precision forestry regeneration	xx	xx		x	4		4		8	1		2	2	5								1	2	3	3		6		9
Big data applications																													
Depth to water (DTW) maps	xx	xx	xx	xx	4	2	6	1	13	1			1	2								2		2	3	1	6		10
Static trafficability map	x	x	xx	xxx	5	2	3	2	12			2		2								1	2	3	3	1	5	1	10
Dynamic soil water map	xx	xx	xx	xx	5	1	4	2	12		1	1	1	3								1	2	3	3	1	6	2	12
Precision planning of environmental considerations	x	xx	xx	xxx	2		2	2	6	1	2	3	1	7								1	1	2	2	1	4	2	9
Optimal routing: Bestway and Ajourakone		x	xxx	xxx	4	1	5	2	12	1	1	1		3								2		2	3		6	1	10
Post-harvest quality control - automatic rut depth measurement by LiDAR				xx	3	1	3		7	2	1	1	2	6		1			1		1	2		3	1	1	4		6
CAN-bus trafficabily mapping			xxx	xxx	5		3	1	9		1	2	1	4							1	1	2	4	3		5		8
Detailed forest yield prediction previous and during harvesting	x	xx	xxx	xxx	3		4		7	2		2	2	6	1				1		1		2	3	3		6		9
Scheduling of harvesting operations			xxx	xx	1		4	1	6	2		1	2	5						2	1		1	4	1		5	2	8

Satisfaction of the Efforte-project

In general, respondents have been satisfied with the outcomes of the project, and moreover, the outcomes of the project have been relevant. In addition, most of the respondents have been agreed on that the project has been efficient in meeting its goals, the collaboration between companies and research bodies as well as within companies has been active and fruitful (Figure 6). In total, only 2 from 17 gave disagreement to the claims related to the a) result relevancy and b) efficiency in meeting project's goals (one per each).
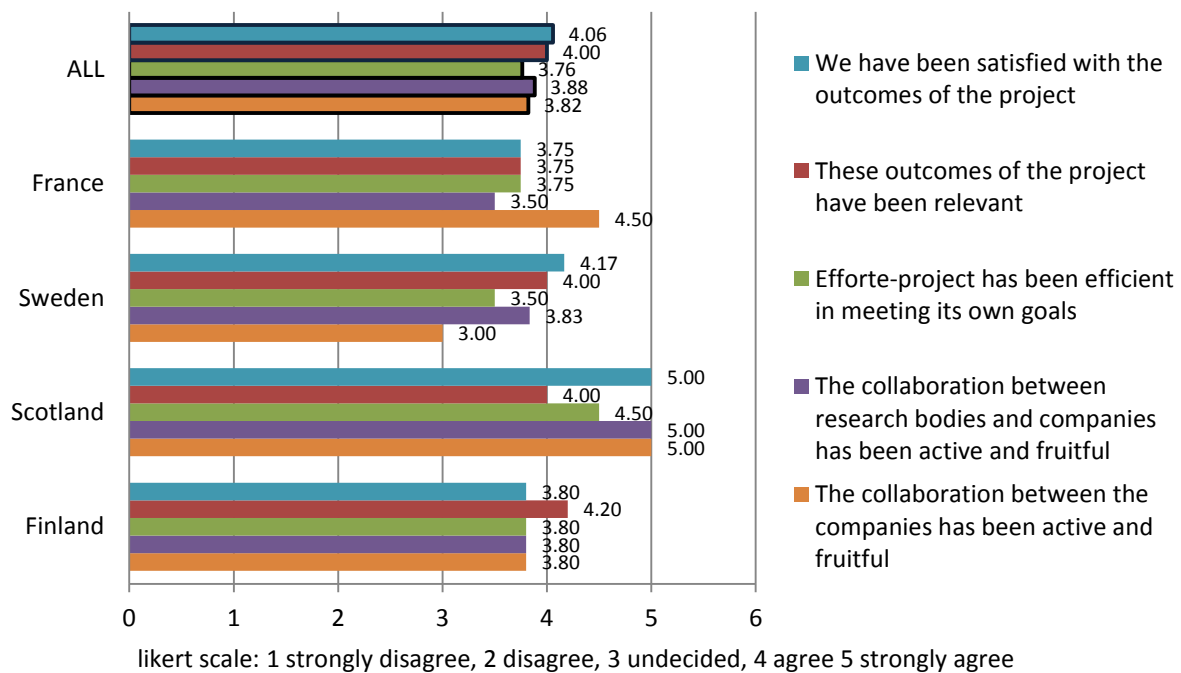

Figure 6. Responds for the satisfaction claims for the Efforte-project. Averages by countries and total.

5. Discussion

To sum up the survey, in general, industrial companies have been satisfied for the overall results of the project; results, relevancy, exploitation of results to practice, dissemination and collaboration between partners. Responds' results were fairly similar between countries with small differences. Thus, this indicates that project outputs have an international interest, or at least European wide. Respondents were, in general, convinced that most of the Efforte-project results can be utilized in operative use in method, model or tool-vice, for example, to be integrated into a forest information system. High exploitation rate of the outcomes to the practice can be seen as the most valuable result of the project evaluation.