Applying the Delphi method to select the sustainable forest harvesting system

Nopparat Kaakkurivaara, Laddawan Rianthakool, Chakrit Na Takuatung, Khanchai Prasanai
Department of Forest Engineering, Faculty of Forestry, Kasetsart University

Operational Level

Sustainable Forest Operations (SFO)

Sustainable Forest Management (SFM)

Sustainable Development (SD)

> The effective implementation of sustainable forest management depends largely on carrying out forest operations in a sustainable manner.

Marchi *et al.* (2018)

Schweier *et al.* (2019)

Thailand

Total forest cover	16,399,000 ha
Certified forests	
Certified areas	
approx.	

Source: FSC (2017)

Thailand

Total forest cover	16,399,000 ha
Certified forests	17 places
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Total forest cover	16,399,000 ha
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Certified areas	61,926 ha
approx.	

Source: FSC (2017)

Thailand

Total forest cover	16,399,000 ha
Certified forests	17 places
Certified areas	61,926 ha
approx.	0.38%

Source: FSC (2017)

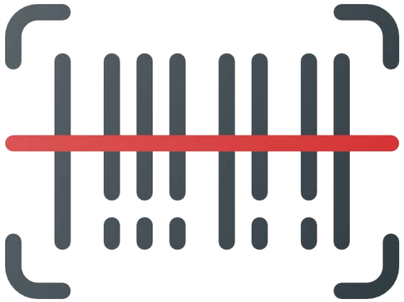
OBSTACLES ?

OBSTACLES

Work Safety

OBSTACLES

Work Safety



Traceability

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3L468
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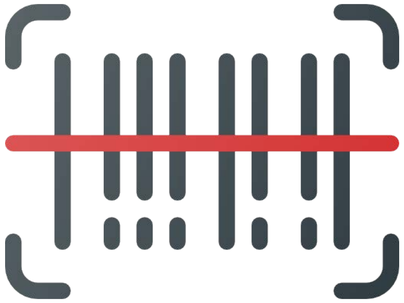
OBSTACLES

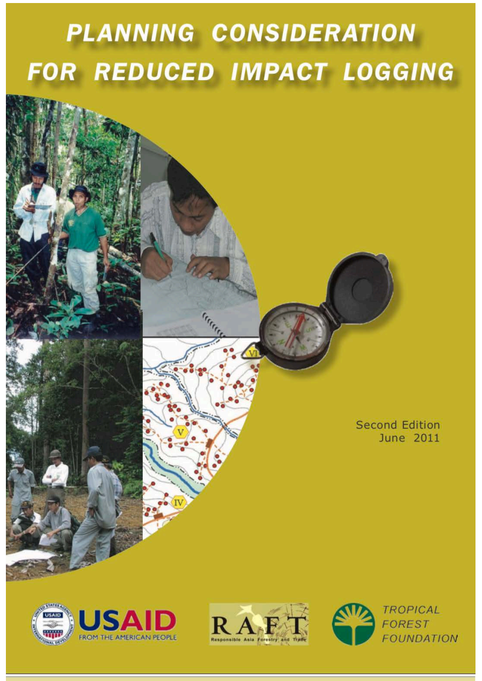
Work Safety

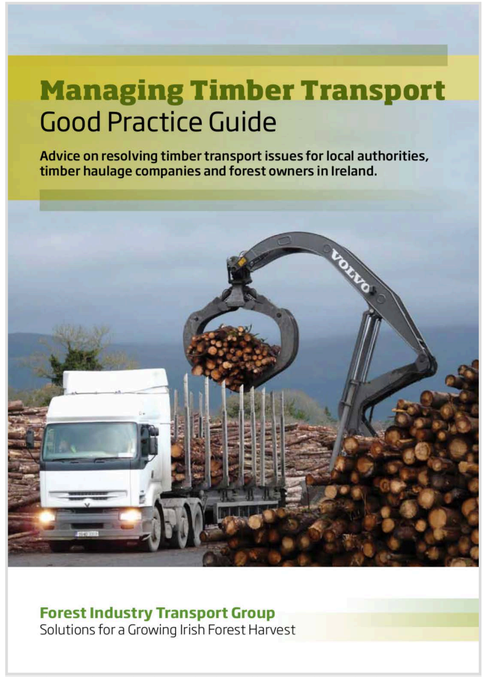


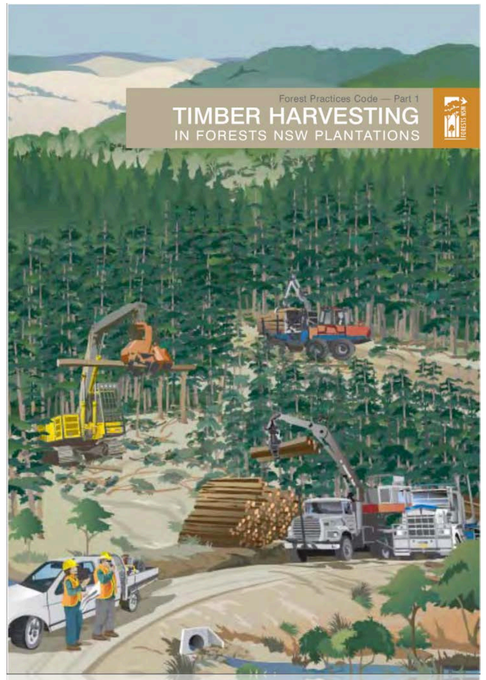
Traceability

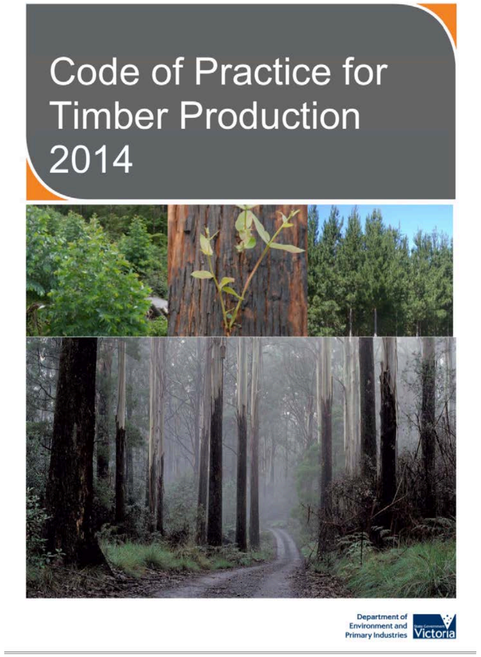
Guidance

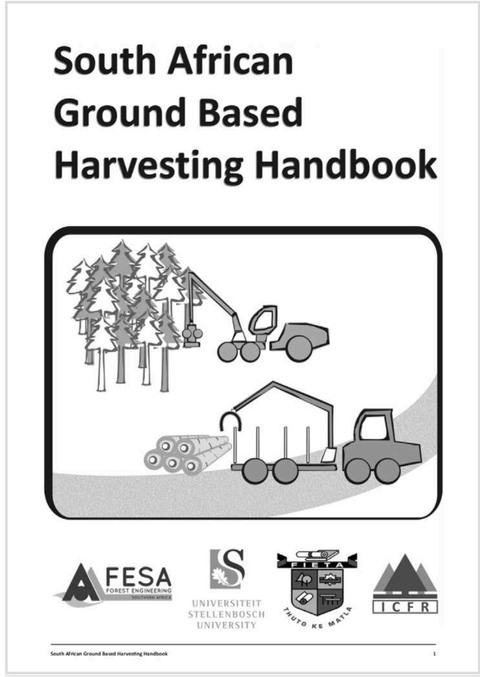
Code of Practice











Good Practice Guide

Code of Practice

(National/Regional level)

Forest ownership

State	25 %
Private	75 %

Forest ownership

State	**25 %**
Private	**75 %**
Large company	18 %
Smallholder	82%

Forest ownership

State	**25 %**
Private	**75 %**
Large company	**18 %**
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Lack of resources

Forest ownership

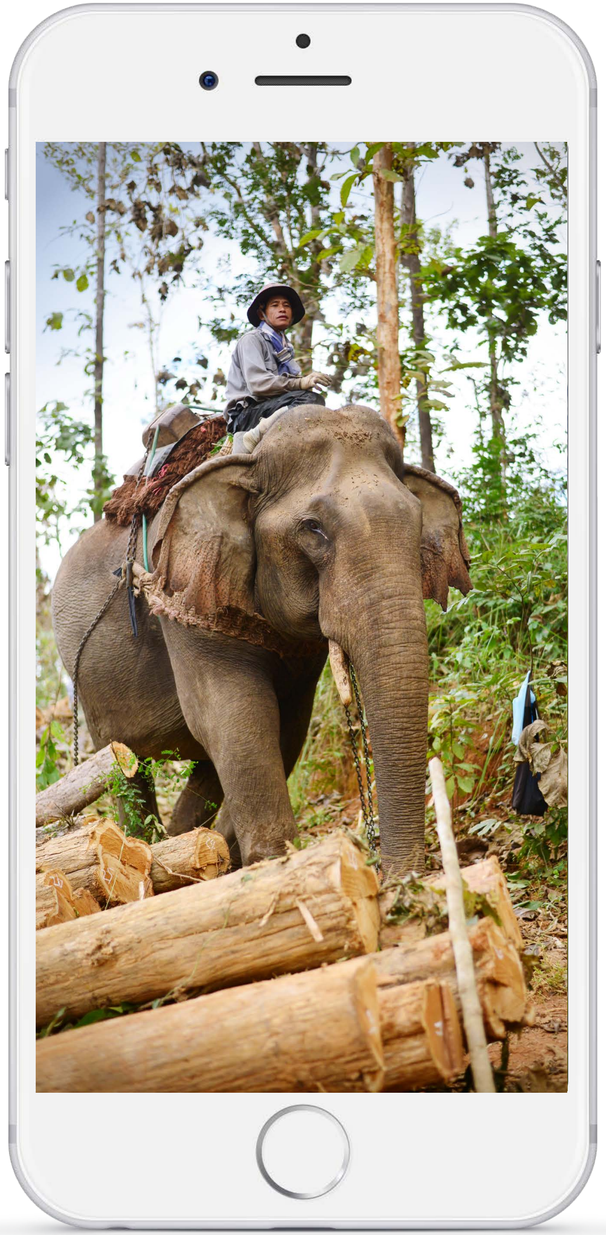
State 25 %

Private 75 %

Large company 18 %

Smallholder 82%

Lack of resources » Simple & Easy tools or methods

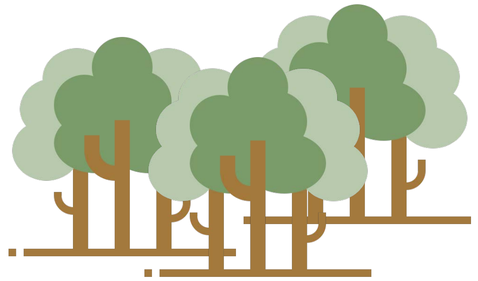
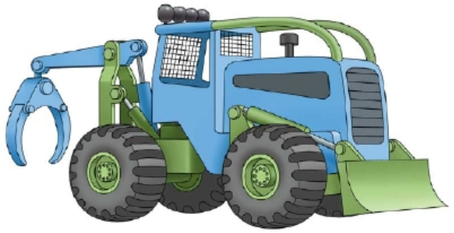


Objectives

- To study a suitable logging system on the basis of sustainable development (economic, societal, and environmental)
- To promote the tools for selecting the sustainble forest operations

Skidder
Photo by Nopparat manavakun

Forest road

	Felling	Skidding	Primary transportation
			
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8	Chainsaw	Elephant & Tractor	Truck & Front ended grapple loader
9	Chainsaw	Elephant & Skidder	Modified Self-loading Truck
10	Chainsaw	Elephant & Skidder	Truck & Front ended grapple loader

Operational Level

Valuation Level

Sustainable Forest Operations (SFO)

Sustainable Forest Management (SFM)

Sustainable indicators (SI)

Economic
- Productivity
- Harvesting cost
- …

Environmental
- Logging impacts (soil, water, standing trees, etc)
- Energy use
- …

Societal
- Accident
- Workload
- Working posture
- …

Sustainable Development (SD)

Schweier et al. (2019)

Operational Level

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- …

The relationship between the sustainability indicators and impact assessment method that can be applied for forest manager and policy makers to select the best technology or system alternative in order to support sustainable development.

Sustainable Development (SD)

Schweier et al. (2019)

Operational Level

Valuation Level

Sustainable Forest Operations (SFO)

Sustainable Forest Management (SFM)

Sustainable indicators (SI)	Tools
Economic • **Productivity** • **Harvesting cost** • …	• Work study • Time study • Cost calculation
Environmental • **Logging impacts** (soil, water, standing trees, etc) • Energy use • …	• Logging impact assessment
Societal • Accident • **Workload** • **Working posture** • …	• Ergonomics study • Heart rate • Body posture analysis

Sustainable Development (SD)

Schweier et al. (2019)

Methodology

PRODUCTIVITY

PRODUCTION COST

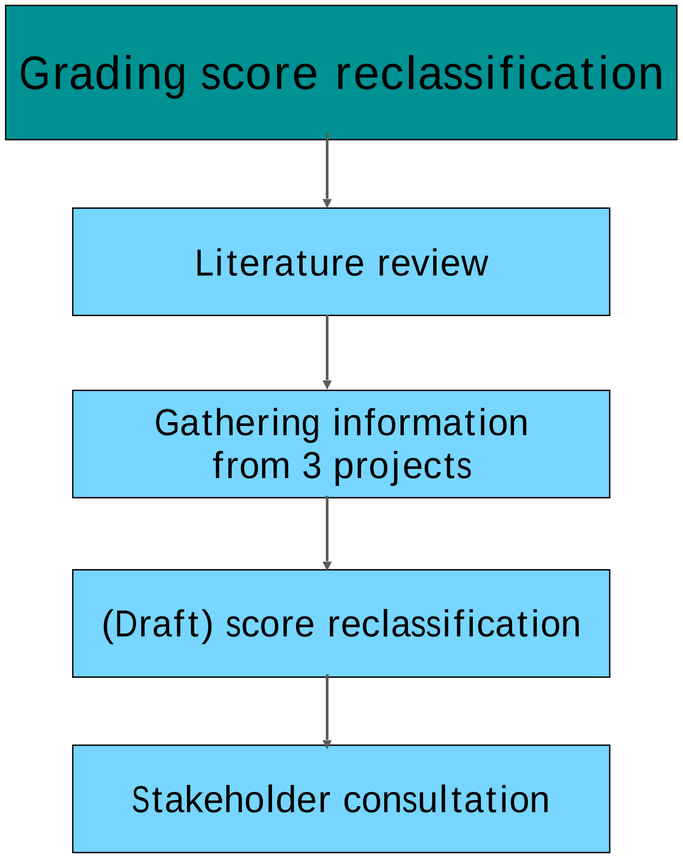
WORKLOAD

WORKING POSTURES

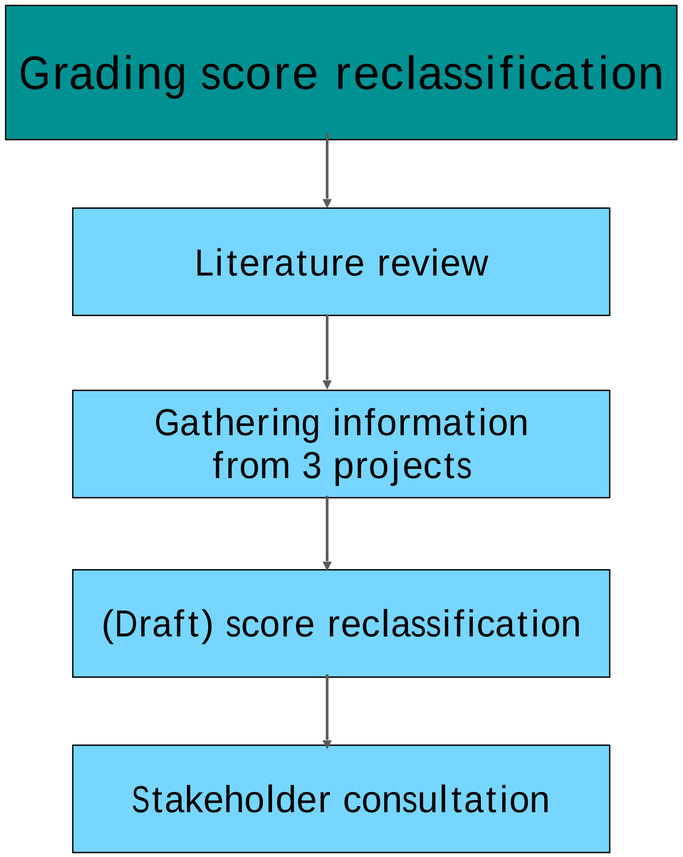
SOIL COMPACTION

SOIL EROSION

Method


Grading score reclassification
Literature review
Gathering information from 3 projects
(Draft) score reclassification
Stakeholder consultation

Method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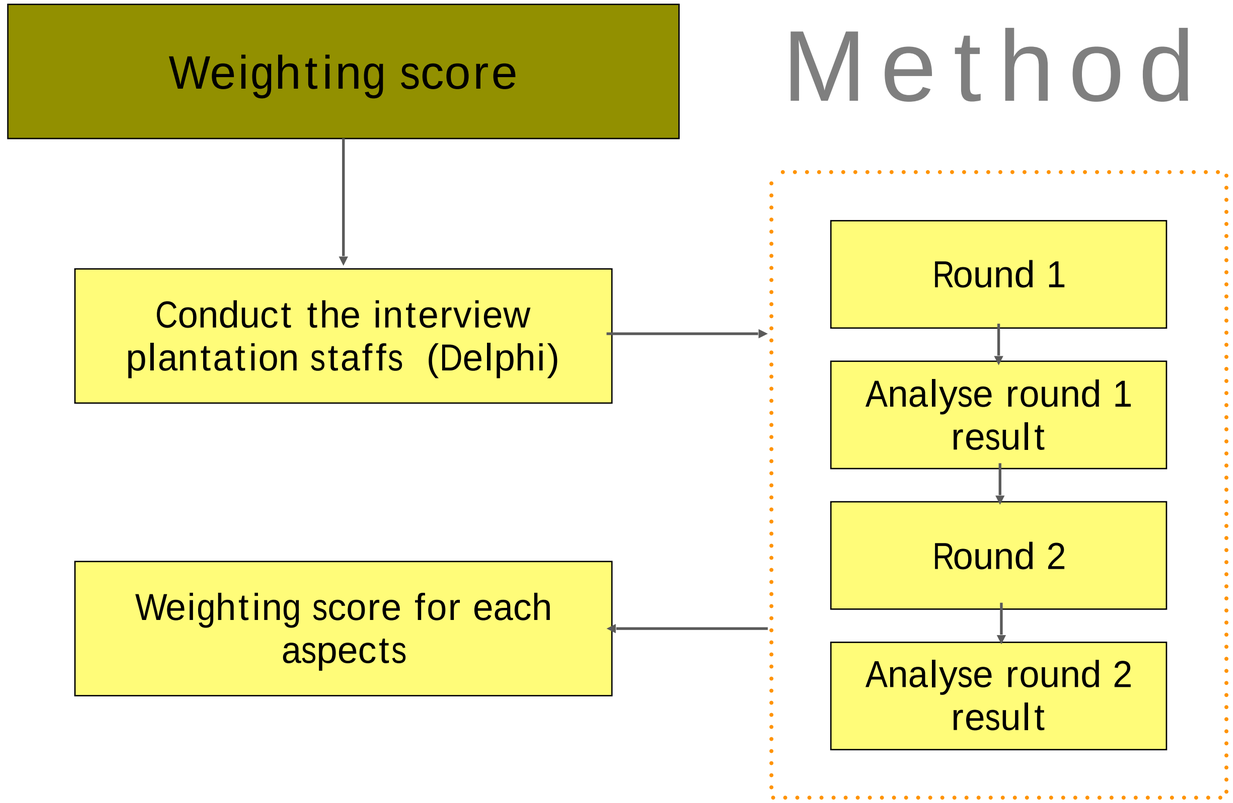
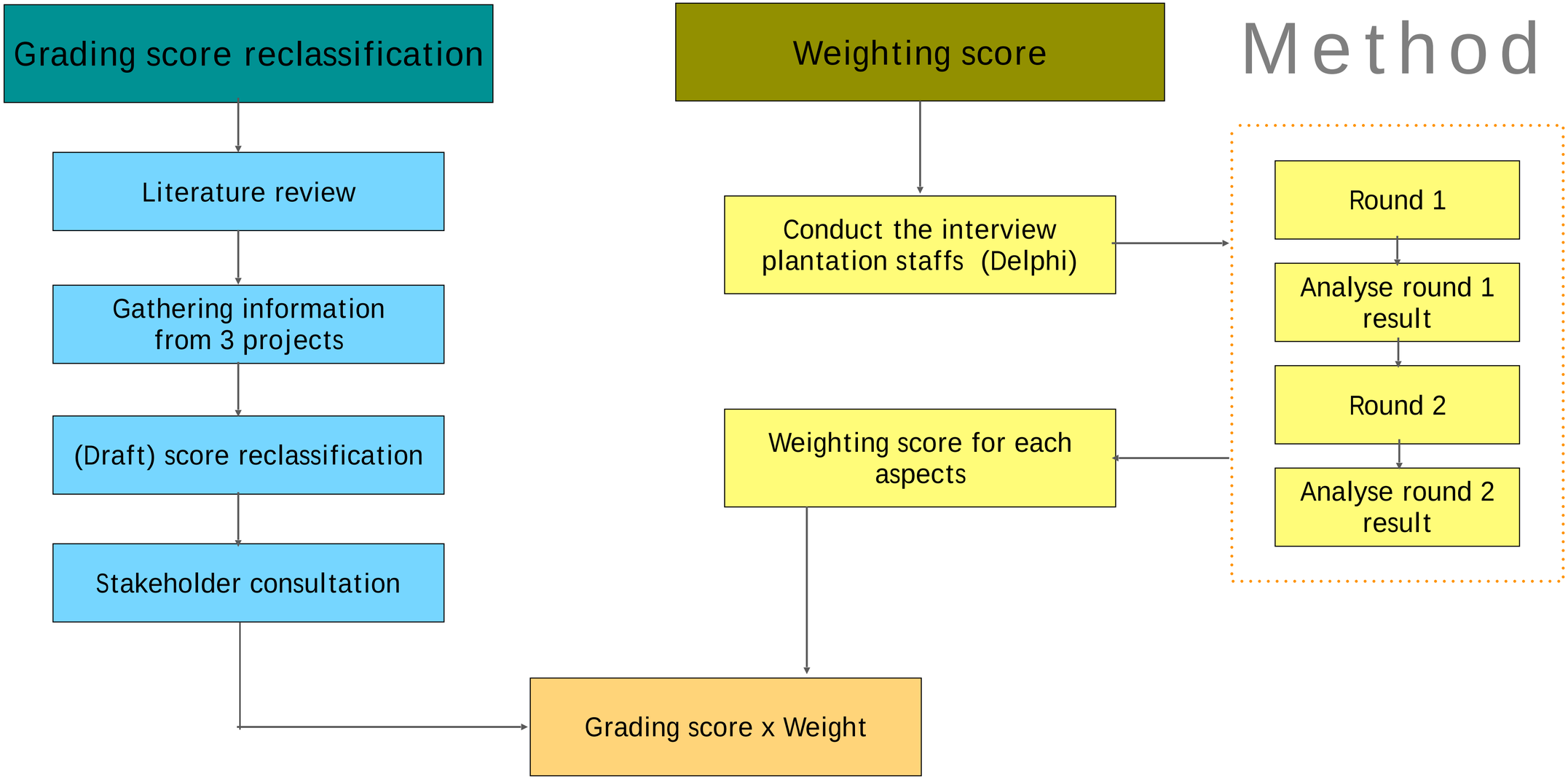

Weighting score
Conduct the interview plantation staffs (Delphi)
Weighting score for each aspects
Round 1
Analyse round 1 result
Round 2
Analyse round 2 result

Method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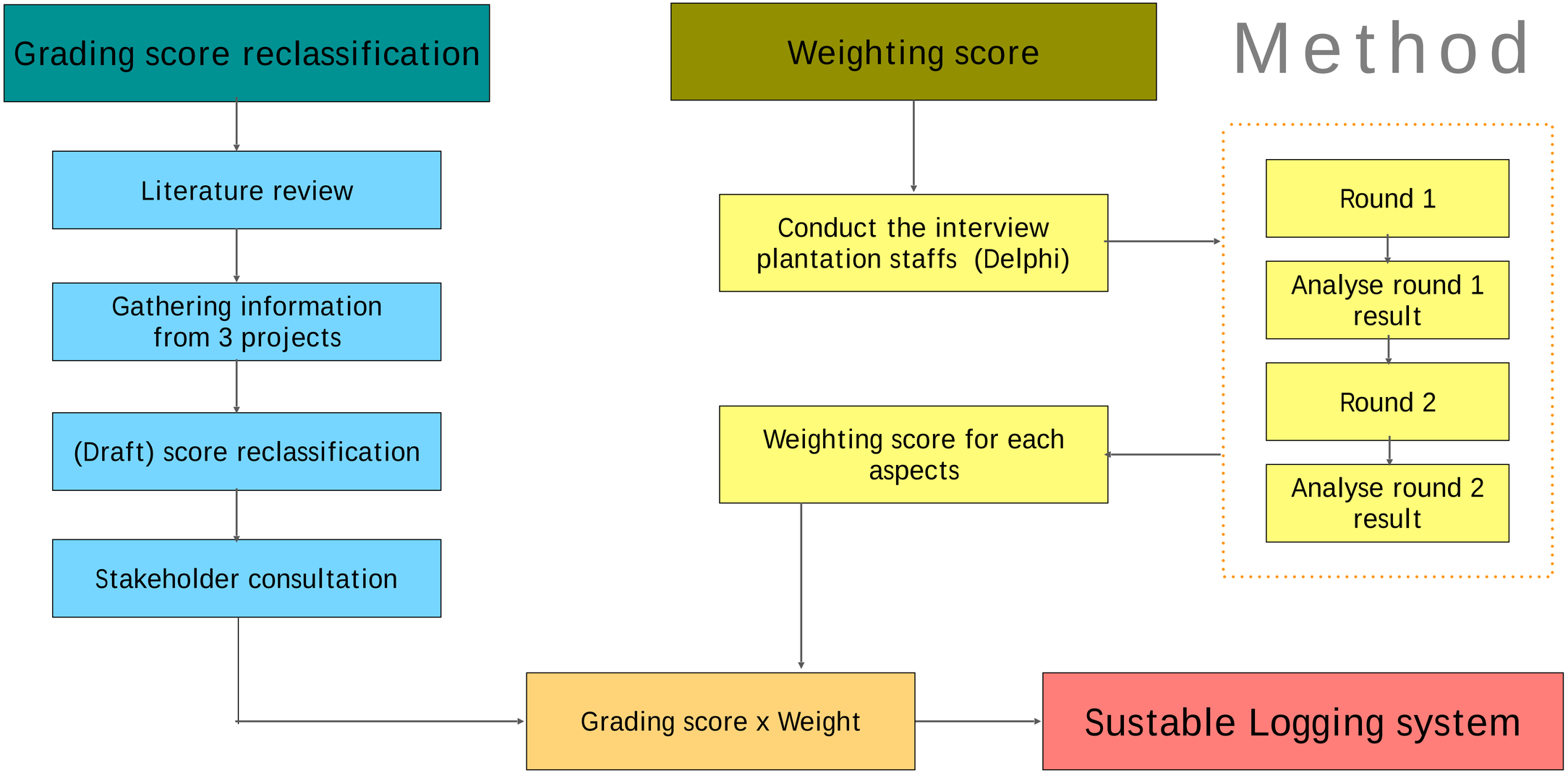
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Sustable Logging system

Grading

Aspect	Grading score				
	1	2	3	4	5
	Critical	Unacceptable	Fair	Good	Excellent
Productivity					
Logging cost					
Heart rate					
Working posture					
Soil compaction					
Soil erosion					

Grading

Aspect	Grading score				
	1	2	3	4	5
	Critical	Unacceptable	Fair	Good	Excellent
Productivity	<5.99 m^3/h	6-10.99 m^3/h	11-15.99 m^3/h	16-20.99 m^3/h	>20.99 m^3/h
Logging cost					
Heart rate					
Working posture					
Soil compaction					
Soil erosion					

Grading

Aspect	Grading score				
	1	2	3	4	5
	Critical	Unacceptable	Fair	Good	Excellent
Productivity	<5.99 m^3/h	6-10.99 m^3/h	11-15.99 m^3/h	16-20.99 m^3/h	>20.99 m^3/h
Logging cost	>900 BTH/m^3	650-900 BTH/m^3	450-649 BTH/m^3	150-449 BTH/m^3	<150 BTH/m^3
Heart rate					
Working posture					
Soil compaction					
Soil erosion					

Grading

Aspect	Grading score				
	1	2	3	4	5
	Critical	Unacceptable	Fair	Good	Excellent
Productivity	<5.99 m^3/h	6-10.99 m^3/h	11-15.99 m^3/h	16-20.99 m^3/h	>20.99 m^3/h
Logging cost	>900 BTH/m^3	650-900 BTH/m^3	450-649 BTH/m^3	150-449 BTH/m^3	<150 BTH/m^3
Heart rate	>80 bpm	76-80 bpm	72-75 bpm	69-71 bpm	<69 bpm
Working posture	>= 11	8.0-10.9	4.0-7.9	2.0-3.9	<2
Soil compaction	>1.8 g/cm^3	1.6-1.8 g/cm^3	1.4-1.6 g/cm^3	1.2-1.4 g/cm^3	<1.2 g/cm^3
Soil erosion	> 9.6 mm/y	7.21-9.60 mm/y	2.41-7.20 mm/y	0.96-2.40 mm/y	<0.96 mm/y

Delphi

Executive

Forest manager

Forest manager assistant

Executive

Forest manager

Forest manager assistant

Delphi

1	6	5	11

Executive

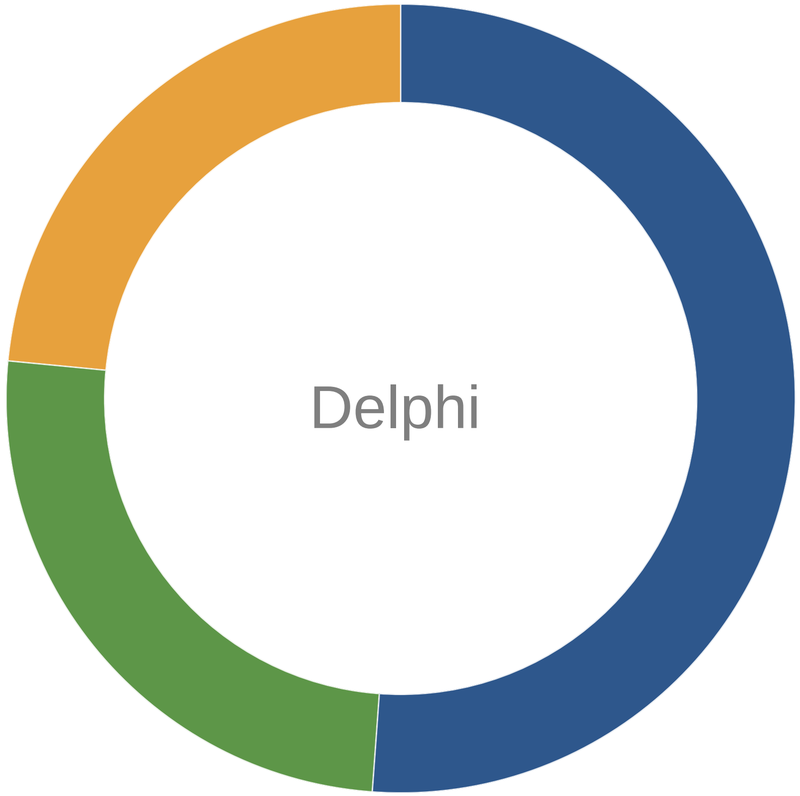
Forest manager

Forest manager assistant

Delphi

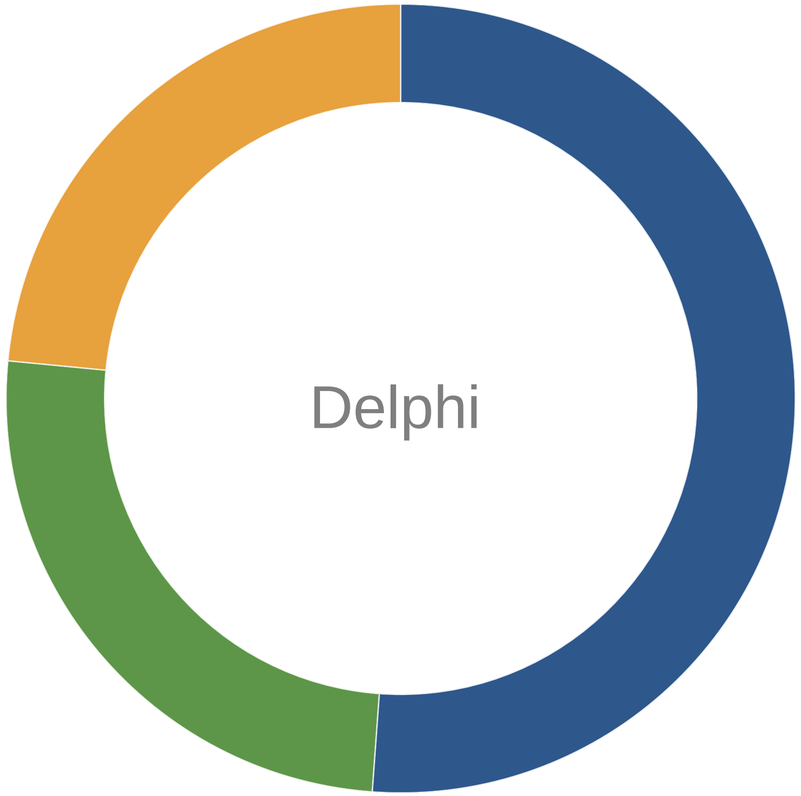
1	6	5	11
2	3	5	11

Weighting score



	Round 1
Economics	**48.6**
Productivity	52.0
Cost	48.0
Societal	**26.8**
Workload	54.5
Working postures	45.5
Environmental	**24.5**
Soil compaction	52.0
Soil erosion	48.0

Weighting score



	Round 1	Round 2
Economics	**48.6**	**51.2**
Productivity	52.0	51.9
Cost	48.0	48.1
Societal	**26.8**	**25.4**
Workload	54.5	54.7
Working postures	45.5	45.3
Environmental	**24.5**	**23.5**
Soil compaction	52.0	55.7
Soil erosion	48.0	44.3

Calculation example for Skidder

Aspect	Info	Grading score	Weight score	Score	Total score
Productivity	17.87 m^3/h	4	0.265	1.061	3.233
Logging cost	229 BTH/m^3	4	0.246	0.983	
Heart rate	91.5 bpm	1	0.139	0.319	
Working posture	5.5	3	0.115	0.345	
Soil compaction	1.45 g/cm^3	3	0.131	0.393	
Soil erosion	4.03 mm/y	3	0.104	0.312	

Total Score

System	Felling	Skidding	Primary transportation	Total score
1	Chainsaw	Elephant	Modified Self-loading Truck	8.958
2	Chainsaw	Tractor	Modified Self-loading Truck	9.488
3	Chainsaw	Skidder	Modified Self-loading Truck	9.063
4	Chainsaw	Elephant	Truck & Front ended grapple loader	9.999
5	Chainsaw	Tractor	Truck & Front ended grapple loader	10.529
6	Chainsaw	Skidder	Truck & Front ended grapple loader	10.104
7	Chainsaw	Elephant & Tractor	Modified Self-loading Truck	9.753
8	Chainsaw	Elephant & Tractor	Truck & Front ended grapple loader	10.794
9	Chainsaw	Elephant & Skidder	Modified Self-loading Truck	9.507
10	Chainsaw	Elephant & Skidder	Truck & Front ended grapple loader	10.548

Total Score

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8	**Chainsaw**	**Elephant & Tractor**	**Truck & Front ended grapple loader**	**10.794**
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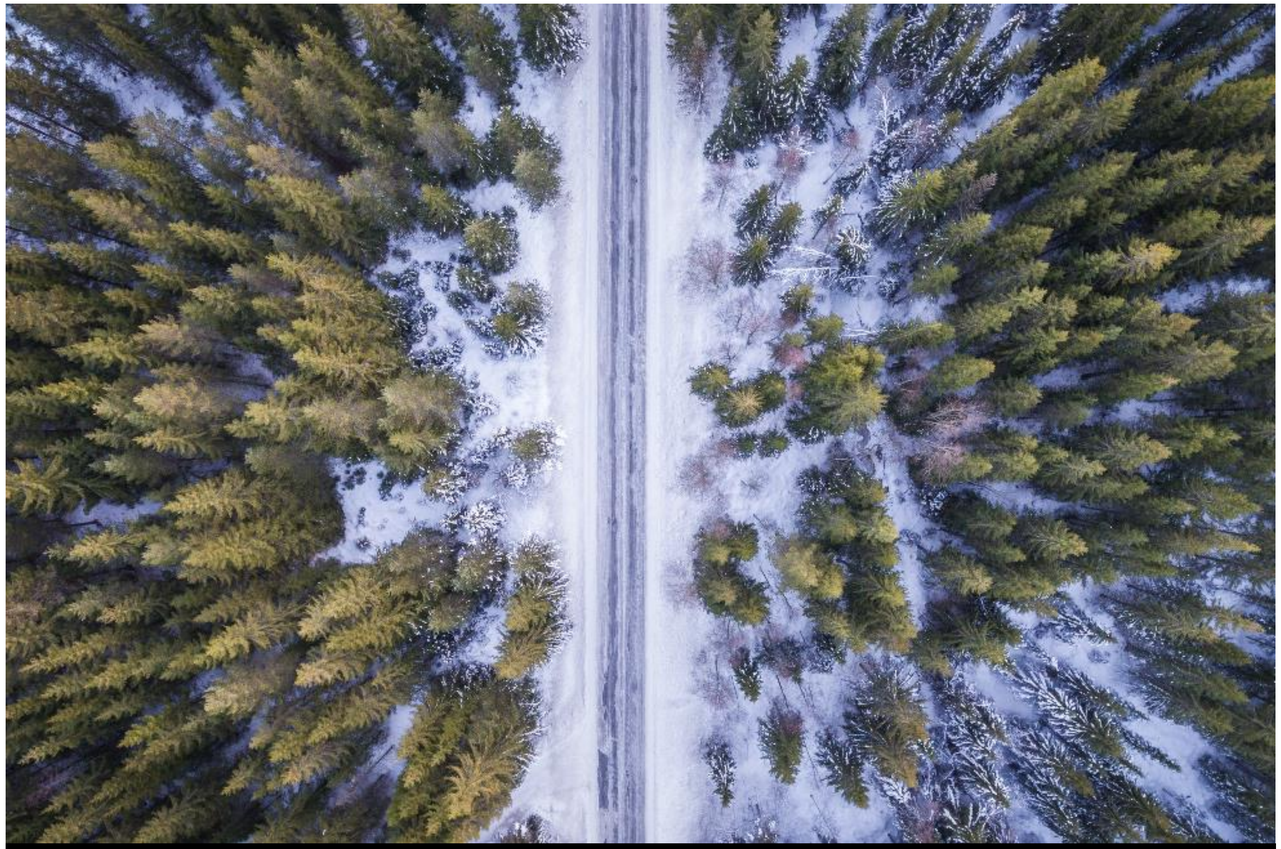
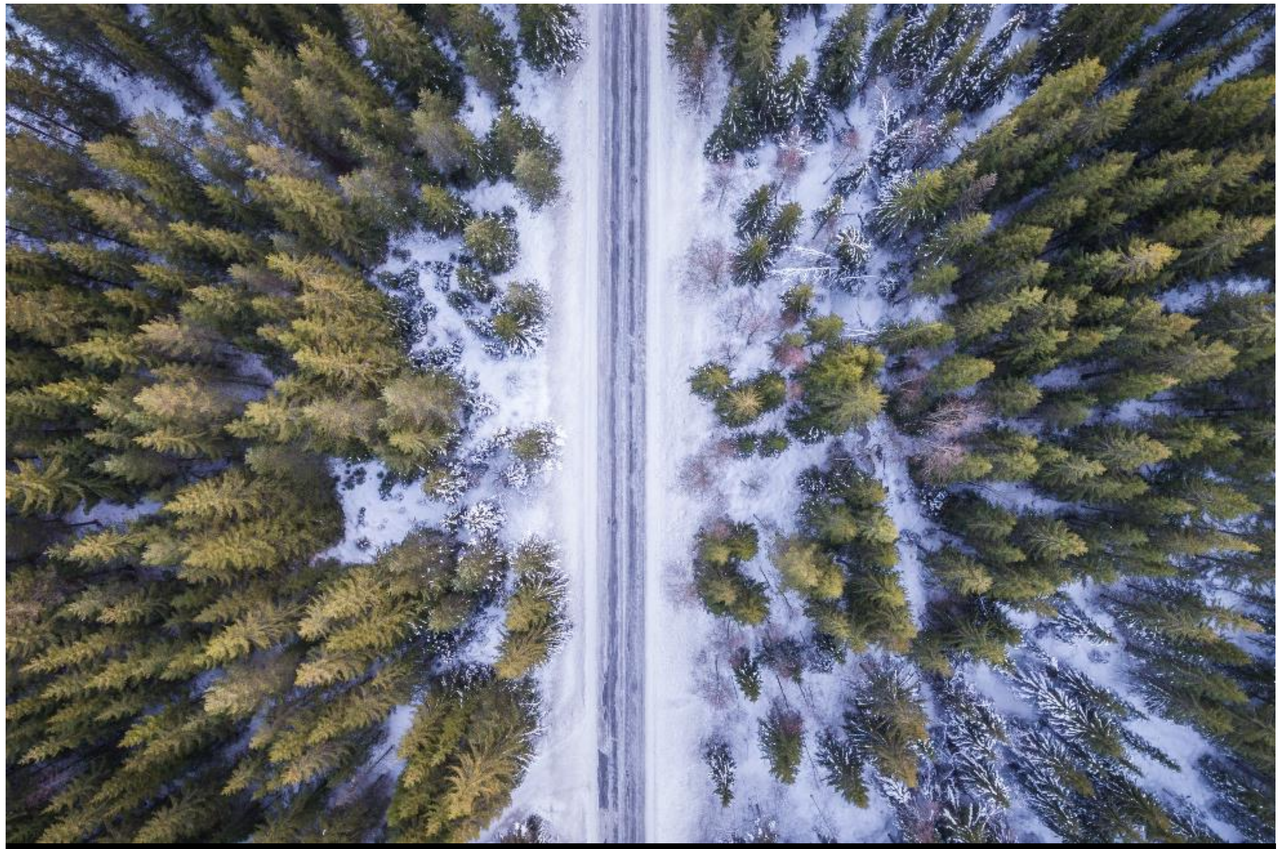


CONCLUSIONS

The recommended logging systems are

- **Chainsaw + Elephant & Tractor + Truck & Front ended grapple loader**

The results may be changed if the weight coefficient is modified



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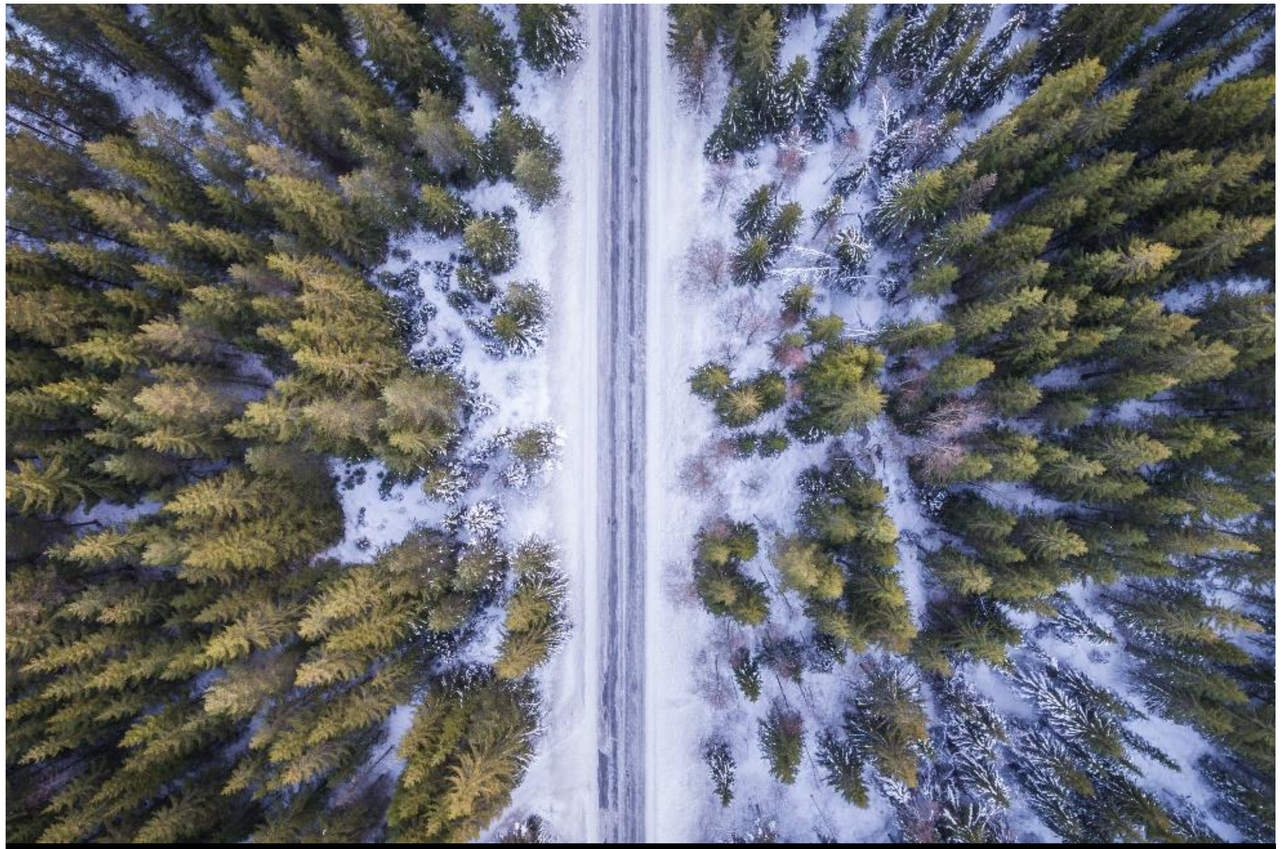
This techniques is a **simple tools** that the forest plantation staffs may apply by themselves.



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The results may be changed if the weight coefficient is modified

This techniques is a simple tools that the forest plantation staffs may apply by themselves.

For precise and visualise results, the GIS shall be applied. However, the skilled staffs are needed in order to analyse the complicated situation via Multi-criteria decision analysis (MCDA) approaches.

Thank you

Nopparat Kaakkurivaara

02-5790169

ffornrm@ku.ac.th