



Sustainability Appraisal of Revegetation Options for Mine Remediation in Northern Canada

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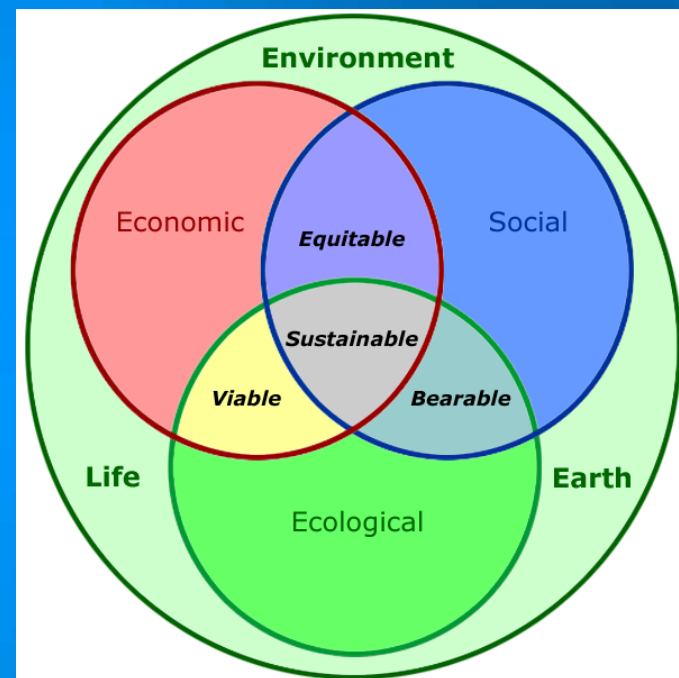
Drivers for Sustainability

- ↳ “cleanup activities use energy, water and material resource to achieve... objectives. The process ... therefore creates an environmental footprint of its own.” (US EPA, 2008)
- ↳ “there is increasing pressure for the regulators of contaminated sites ... to consider net impacts as part of their criteria” (SURF-US, 2009)

Sustainable Remediation

“the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected”

(CL:AIRE, 2010)



Gunnar Uranium Mine Site

- ✓ Uranium mine and mill
- ✓ Operated 1953-1964
- ✓ SRC manages the decommissioning and rehabilitation of the site



Gunnar Site Remediation Project

- 82 ha of unconfined tailings in 3 locations
- to be capped with engineered cover
- revegetation with native plants
 - ✓ End-point: grass-legume community with 60-80% cover



Previous Related Studies

1. Field trial of natural recovery of borrow area at Gunnar



2. Greenhouse and field trials of soil amendments:

- ✓ Borrow material proposed for tailing cover (low carbon sand and gravel mixture)
- ✓ Amendments: peat, biochar, NPK
- ✓ Native plant species



3. Biochar production:

- ✓ Fast/slow pyrolysis units
- ✓ various feedstock



Revegetation Options

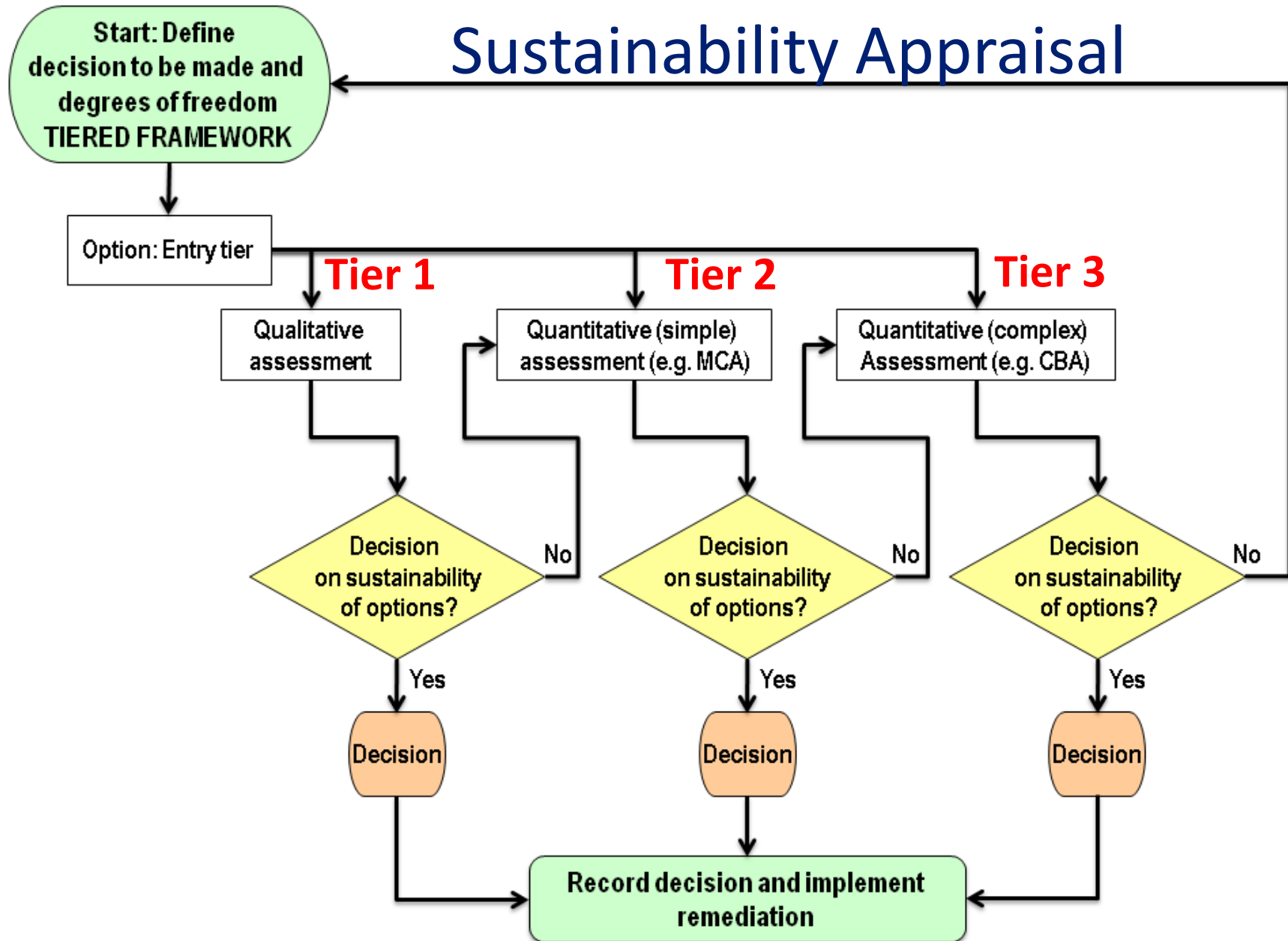


Natural Recovery	Peat	Commercial Biochar	Local Biochar
Implement wind erosion control	Apply peat to increase topsoil organic matter content to 2%	Apply biochar to increase topsoil organic matter content to 2%	Apply biochar to increase topsoil organic matter content to 2%
<ul style="list-style-type: none"> • Wind breakers procurement, installation, and maintenance • Tree suppression • Weed mgmt. 	<ul style="list-style-type: none"> • Peat procurement and application • Fertilizer application • Seeding 	<ul style="list-style-type: none"> • Biochar procurement and application • Fertilizer application • Seeding 	<ul style="list-style-type: none"> • Mobile pyrolysis unit procurement and operation • Biochar production and application • Fertilizer application • Seeding
>10 years	2-3 years	2-3 years	2-3 years

Study Objectives

- ↳ Carry out a sustainability appraisal to compare the economic, environmental and societal attributes of revegetation options for a case study
- ↳ Test tiered sustainability appraisal method

Tiered Approach to Sustainability Appraisal



Courtesy of: Jonathan Smith and Paul Bardos (CL:AIRE, 2010)

Tier 1 – Qualitative Screening Expert Panel Review - Methods

↳ Panel Composition

- ✓ Two environmental engineers
- ✓ Socio-economic specialist
- ✓ Revegetation specialist

↳ Methods

- ✓ Document review
- ✓ Consultation with interested parties
- ✓ Option scoring (from 1 to 4)
- ✓ 19 Criteria

Assessment Criteria		
Environmental	Social	Economic
<ul style="list-style-type: none"> ✓ Biodiversity Footprint ✓ Air Quality ✓ Energy Consumption ✓ Greenhouse Gases ✓ Carbon Sinks ✓ Waste Generation 	<ul style="list-style-type: none"> ✓ Occupational Risks ✓ Site Aesthetic ✓ Land Use ✓ Public Safety ✓ Community Perception ✓ Community Involvement 	<ul style="list-style-type: none"> ✓ Project cost ✓ Project risks ✓ Economic Opportunities ✓ Province Revenue ✓ Job Opportunities ✓ Job Diversity ✓ Technical Feasibility

Tier 1 – Qualitative Screening: Expert Panel Review - Results

Environmental

Social

Economic

Criterion	Option 1	Option 2	Option 3	Option 4
	Natural revegetation	Revegetation with Peat Application	Revegetation with Commercial Biochar	Revegetation with Local Biochar
Biodiversity Footprint	Yellow	Yellow	Yellow	Yellow
Air Quality	Yellow	Yellow	Yellow	Yellow
Greenhouse Gases	Yellow	Yellow	Red	Yellow
Energy Consumption	Yellow	Yellow	Yellow	Yellow
Carbon Sinks	Yellow	Yellow	Yellow	Yellow
Waste Generation	Yellow	Yellow	Yellow	Yellow

Criterion	Option 1	Option 2	Option 3	Option 4
	Natural revegetation	Revegetation with Peat Application	Revegetation with Commercial Biochar	Revegetation with Local Biochar
Occupational Risks	Yellow	Yellow	Yellow	Yellow
Site Aesthetic	Yellow	Green	Yellow	Yellow
Public Safety	Red	Green	Yellow	Yellow
Land Use	Yellow	Green	Yellow	Yellow
Community Perception	Yellow	Yellow	Yellow	Green
Community Involvement	Yellow	Yellow	Yellow	Green

Criterion	Option 1	Option 2	Option 3	Option 4
	Natural revegetation	Revegetation with Peat Application	Revegetation with Commercial Biochar	Revegetation with Local Biochar
Project cost	Yellow	Red	Red	Yellow
Project risks	Red	Green	Yellow	Yellow
Economic Opportunities	Red	Yellow	Yellow	Yellow
Province Revenue	Yellow	Yellow	Yellow	Yellow
Job Opportunities	Yellow	Yellow	Yellow	Yellow
Job Diversity	Yellow	Yellow	Yellow	Yellow
Technical Feasibility	Green	Green	Yellow	Yellow

Overall Outcome

Aspect	Option 1	Option 2	Option 3	Option 4
	Natural revegetation	Revegetation with Peat Application	Revegetation with Commercial Biochar	Revegetation with Local Biochar
Environmental	the most preferred option	the second-preferred option	the least preferred option	the most preferred option
Social	the least preferred option	the second-preferred option	the less preferred option	the most preferred option
Economic	the least preferred option	the most preferred option	the second-preferred option	the second-preferred option
Overall Results	the least preferred option	the second preferred option	the least preferred option	the most preferred option

Tier 2 – Semi-Quantitative Screening Stakeholder Survey - Methods

↳ Participants (internal to SRC)

- ✓ Aboriginal and local community
- ✓ Decision maker
- ✓ Environmental consultant
- ✓ Technical specialist
- ✓ Finance specialist

↳ Methods

- ✓ Multiple-Criteria Decision Analysis
- ✓ 9 Criteria

Assessment Criteria		
Environmental	Social	Economic
<ul style="list-style-type: none"> ✓ Biodiversity Footprint ✓ Air Quality ✓ Greenhouse Gases 	<ul style="list-style-type: none"> ✓ Occupational Risks ✓ Land Use ✓ Community Involvement 	<ul style="list-style-type: none"> ✓ Project cost ✓ Project risks ✓ Economic Opportunities

Tier 2 – Semi-Quantitative Screening Stakeholder Survey - Methods

Multiple Criteria Decision Analysis

- ✓ Expert Choice (web-based software)
- ✓ Pairwise comparisons

With respect to **Social Criterion 1: Occupational risks** which of the two alternatives below is more preferable

☑ Social Criterion 1: Occupational risks ✎

This criterion comprises minimization of risks associated with carrying out the project.
Factors to be considered:

- Transportation to site
- On-site operations
- Working at a remote, poorly accessible site

Natural Revegetation **Local Biochar**

Extremely Very strongly Strongly Moderately Equal Moderately Strongly Very strongly Extremely

☑ Social Crit ✎

This criterion comprises minimization of risks associated with carrying out the project.
Factors to be considered:

☑ Natural Revegetation ✎

installation of wind breaks and site natural recovery accompanied with tree suppression and active weed management

☑ Local Biochar ✎

application of locally produced biochar, fertilizer application, and native plant seeding

Eraser Judgment

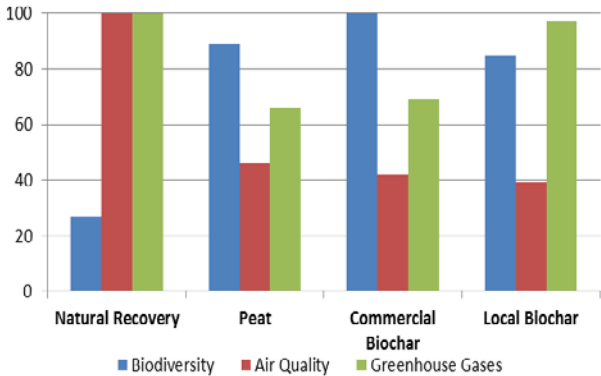
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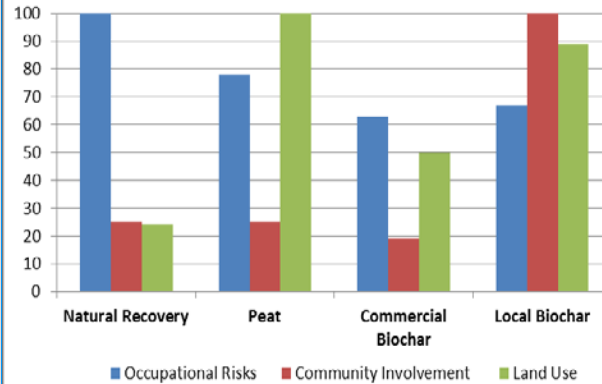
Tier 2 – Semi-Quantitative Screening Stakeholder Survey - Results

Option Comparison

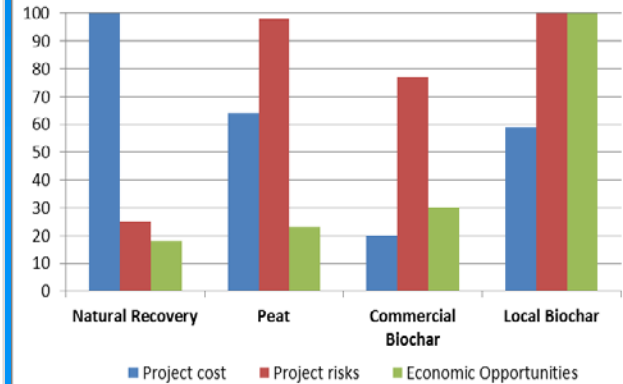
Environmental Criteria



Social Criteria

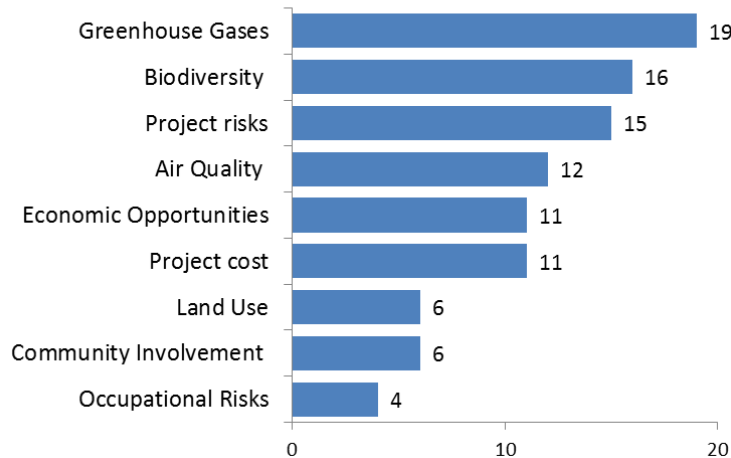


Economic Criteria

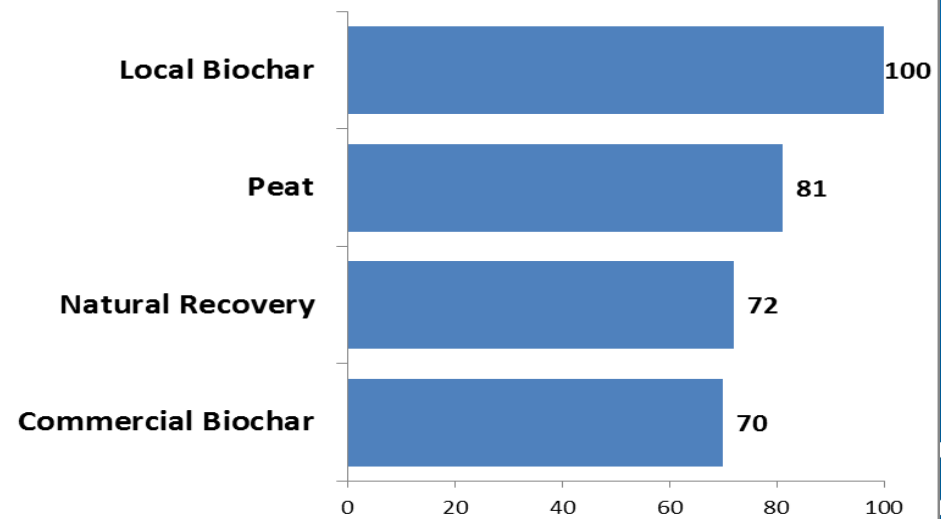


Criterion Comparison

Weighting Factor (%)



Overall Outcome



Tier 3 – Quantitative Analysis

LCA and LCC Screening

↳ 3 options examined

- ✓ Peat
- ✓ Local Biochar
- ✓ Commercial Biochar

↳ Two analyses

- ✓ Screening Life Cycle Assessment (LCA)
- ✓ Screening Life Cycle Cost Analysis (LCC)

↳ Models based on readily and publicly available information

Tier 3 – Quantitative Analysis

LCA and LCC Screening

↳ Revegetation of the largest Gunnar tailing (53 ha)

↳ Focused on differences

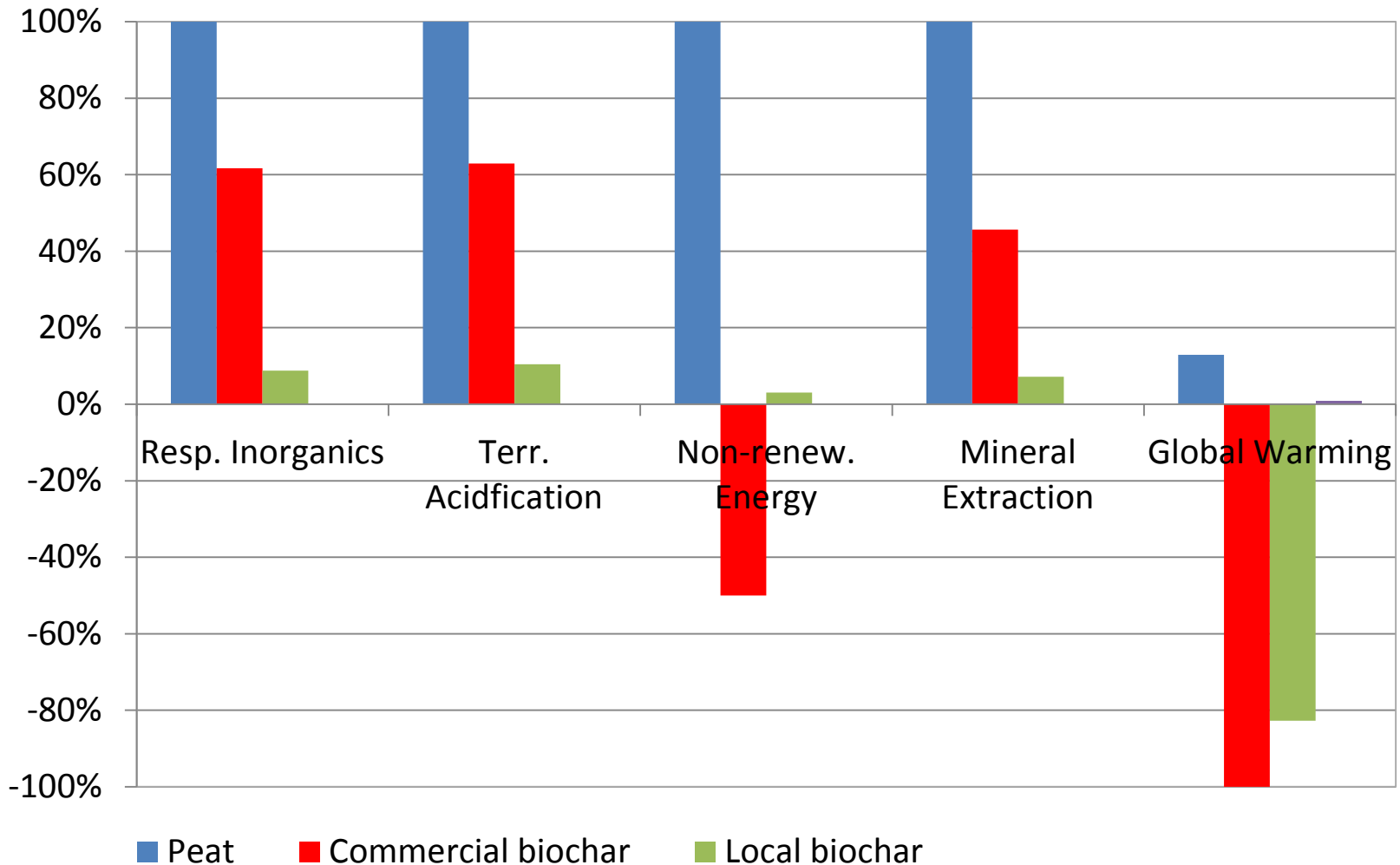
➤ Excluded

- ✓ activities similar between the revegetation options (e.g. seeding, fertilizing, monitoring)

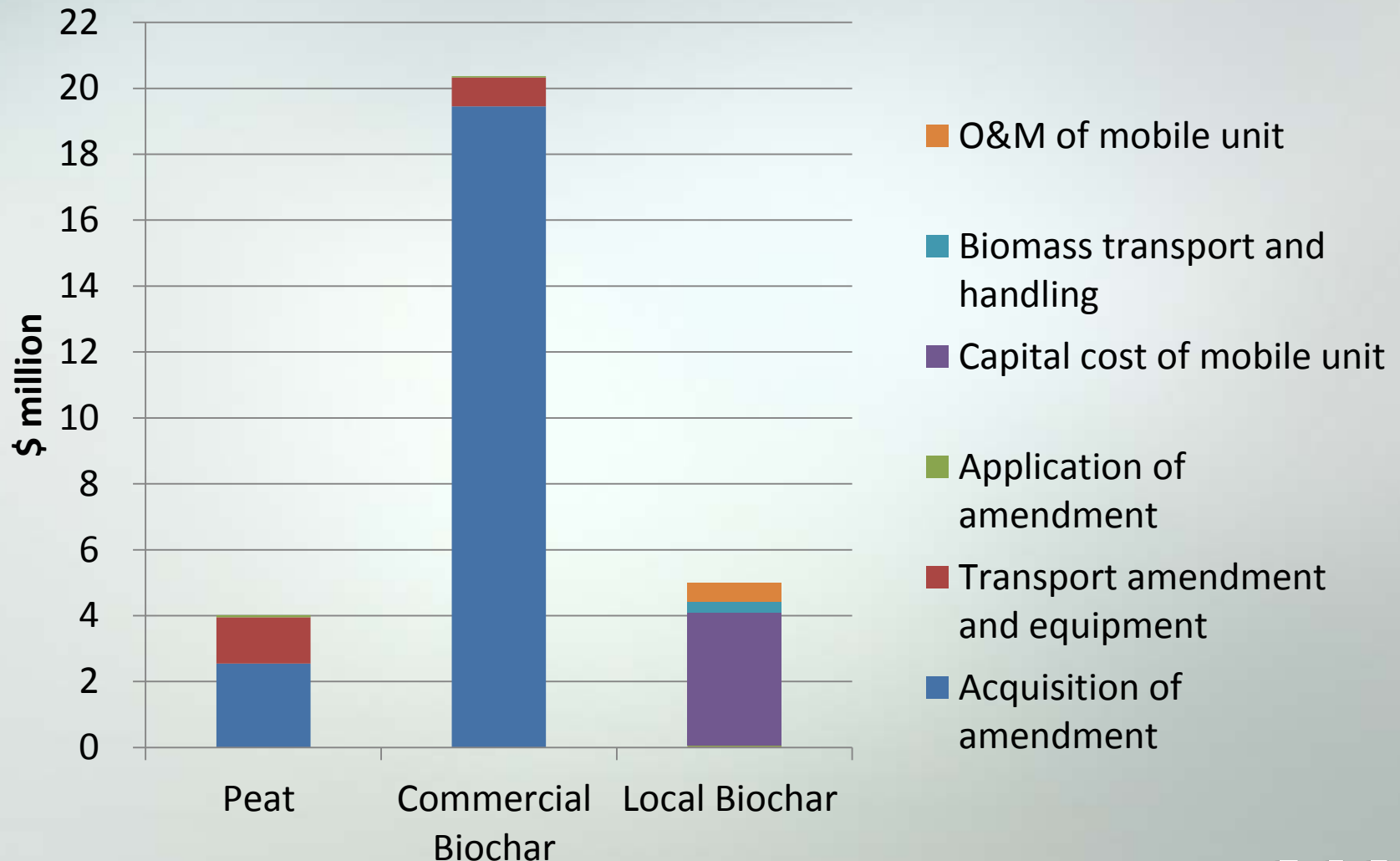
➤ Included

- ✓ Organic soil amendment acquisition and application
- ✓ Transport of materials and personnel
- ✓ Equipment operation and maintenance

Tier 3 – Quantitative Analysis Life Cycle Assessment



Tier 3 – Life cycle cost - Results



Tier 3 – Quantitative Analysis

LCA and LCC Screening

↳ No immediate answer

- Biochar options more environmentally preferable
- Peat the most cost-effective

↳ Limitations:

- Outcome sensitive to assumptions

Sustainability Appraisal - Conclusions

- ↳ Local Biochar – most preferred option
 - Socially acceptable
 - Environmental gains and economic opportunities
 - But more costly and higher technical risks than peat
- ↳ Key lessons
 - Improved understanding of the sustainability gaps of the project
 - “Sustainable” is a relative term
 - Stakeholders participation is key
 - Trade-offs
- ↳ Sustainability appraisal approach
 - Strong method to apply sustainability to a wide range of projects
 - Goes beyond common evaluation criteria
 - Provides information to support decision making
 - Should be integrated at onset of a project



Paper *“Environmental, Social, and Economic Benefits of Biochar Application for Land Reclamation Purposes”* (Petelina et al., 2014) is available in proceedings of the BC 2014 Mine Reclamation Symposium.

References

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- ↳ [US EPA], US Environmental Protection Agency, 2008. Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites.