

Quantitative Life Cycle Assessment (QLCA) for natural fibre vs glass fibre as the reinforcement in composites

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Research Objective:

- Comparative quantitative LCA for glass and flax
- Are natural fibres truly environmentally preferable to manmade fibres when used as the reinforcement in composites?



Production Processes:

Flax

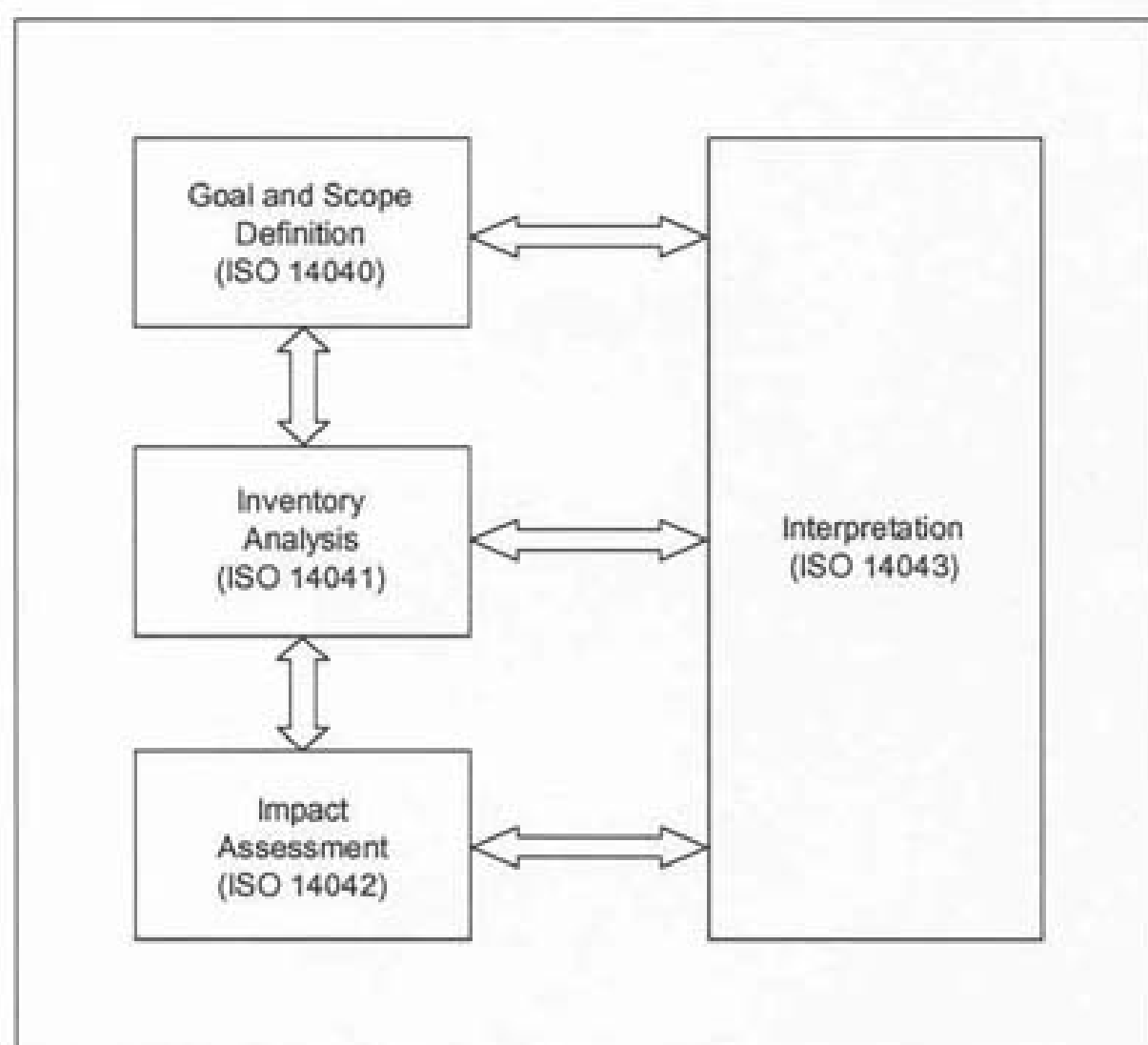
- Ploughing & drilling
- Applying fertiliser
- Weed & pest control
- Decortication
- Harvest
- Rippling
- Retting
- Decortication

Glass

- Raw material processing (crushing, weighing, mixing)
- Melting
- Spinning
- Forming
- Curing
- Cooling
- Weaving

Life Cycle Assessment (LCA)

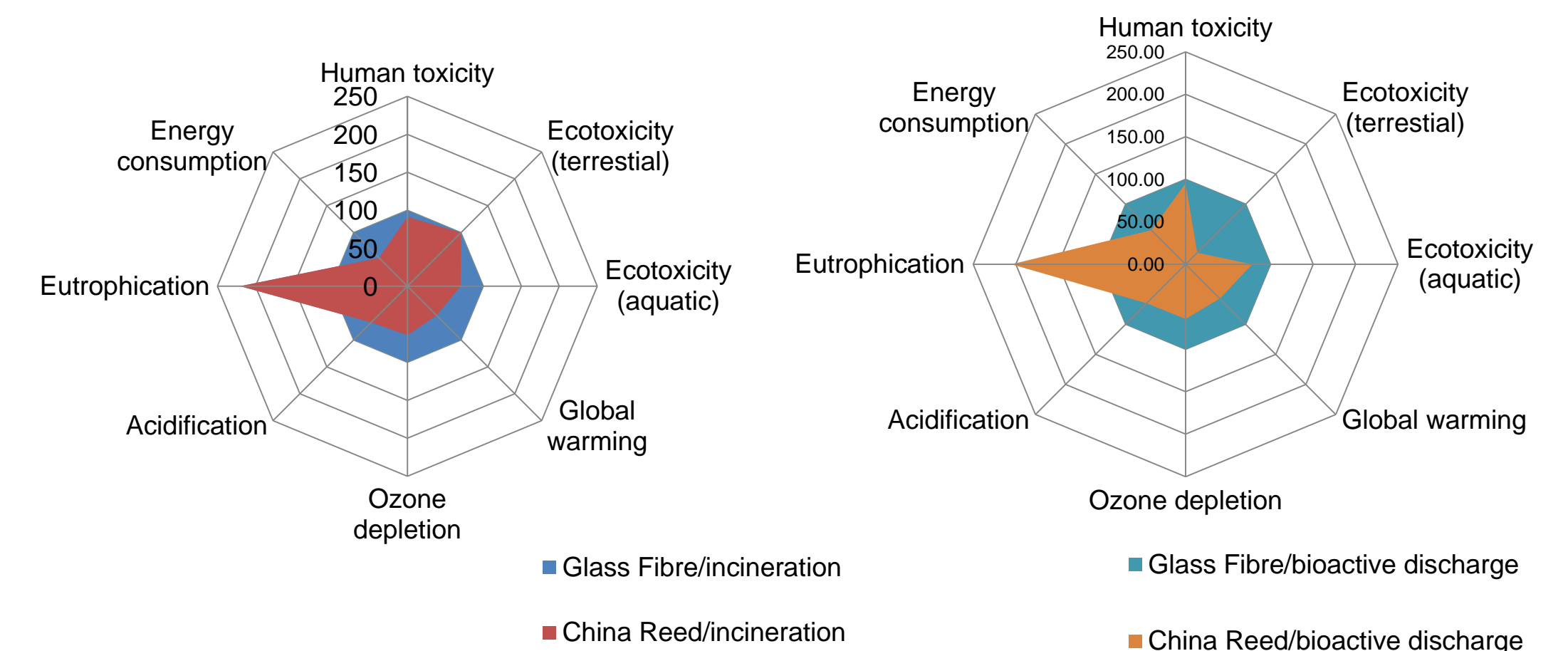
Life Cycle Assessment Framework



Environmental Impact Categories

| ISO/TR 14047:2003(E) | Azapagic et al |
|---------------------------------------|--|
| Acidification | Acidification Potential (AP) |
| Ecotoxicity | Aquatic Toxicity Potential (ATP) |
| Eutrophication / Nitrification | Eutrophication Potential (EP) |
| Climate Change | Global Warming Potential (GWP) |
| Human Toxicity | Human Toxicity Potential (HTP) |
| Depletion of abiotic/biotic resources | Non-Renewable / Abiotic Resource Depletion (NRADP) |
| Stratospheric ozone depletion | Ozone Depletion Potential (ODP) |
| Photo-oxidant formation | Photochemical Oxidants Creation Potential (POCP) |

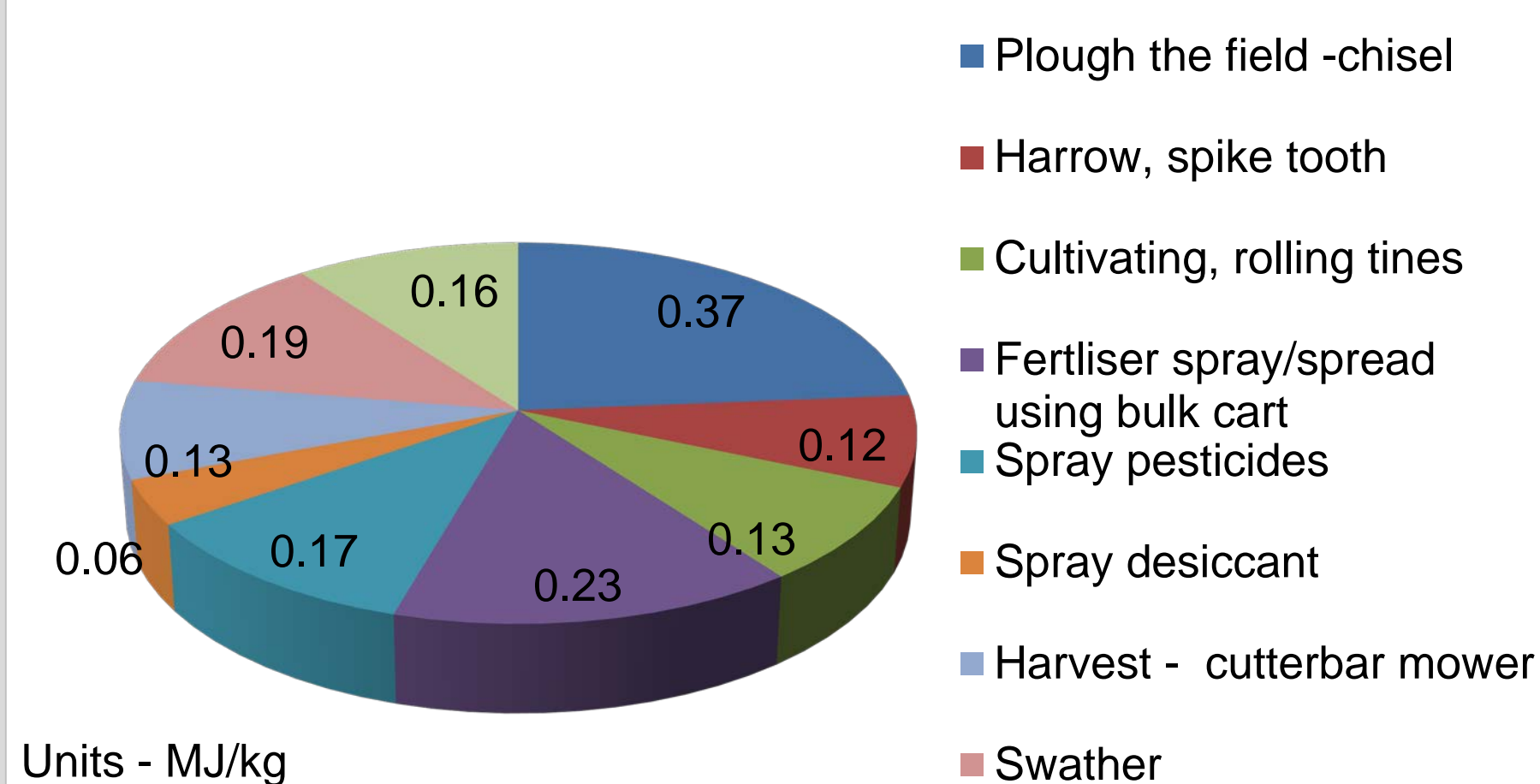
Life Cycle Impact Assessment – Previous Study Corbière-Nicollier on China Reed vs Glass



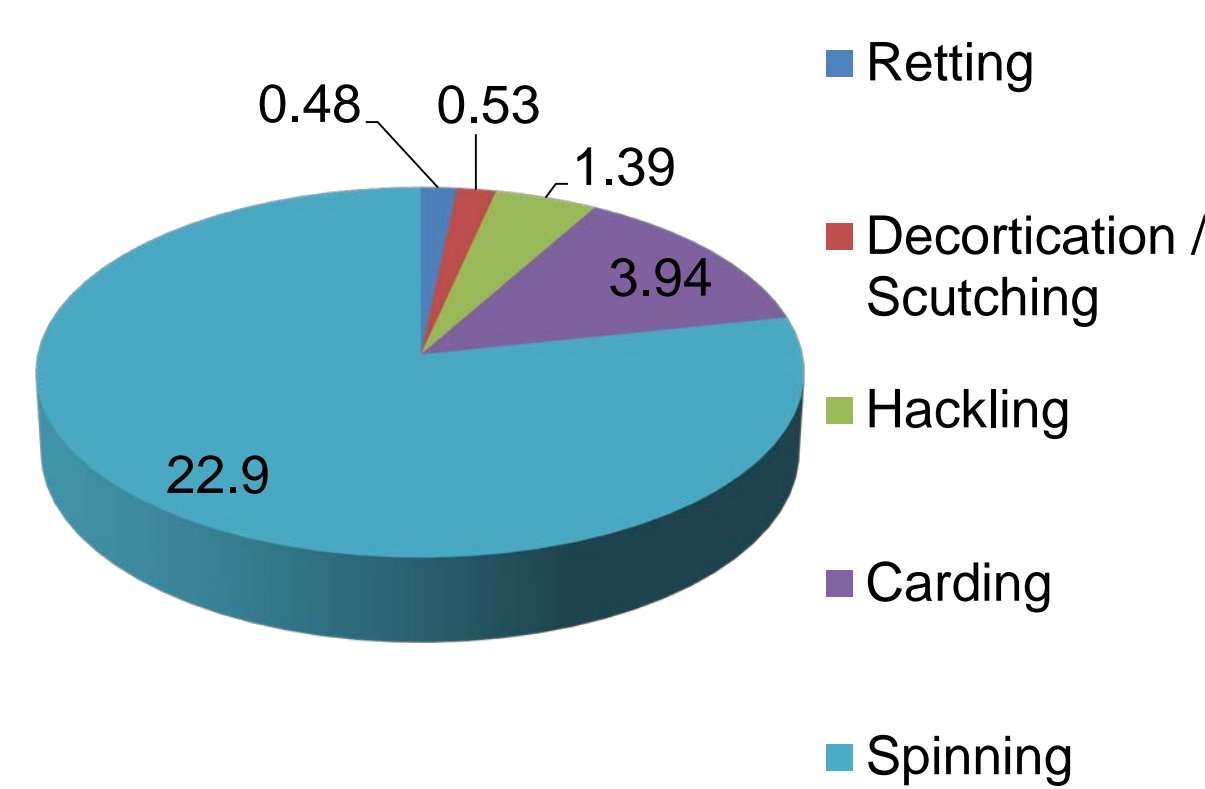
Results

Life Cycle Inventory Analysis (flax)

Flax – Agricultural Operations - Energy use



Fibre Processing Operations



Qualitative Life Cycle Impact Assessment

For flax fibre production process (key issues):

| Environmental Impact Classification Factor | Ploughing | Sowing | Water | Herbicides | Pesticides | Fertiliser | Decortication | Harvest | Rippling | Retting | Decortication | Hackling | Carding | Spinning |
|--|-----------|--------|-------|------------|------------|------------|---------------|---------|----------|---------|---------------|----------|---------|----------|
| Acidification Potential (AP) | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| Aquatic Toxicity Potential (ATP) | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| Eutrophication Potential (EP) | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| Global Warming Potential (GWP) | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| Human Toxicity Potential (HTP) | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| Non-Renewable/Abiotic Resource Depletion (NRADP) | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |

For glass fibre production process (key issues):

| Environmental Impact Classification Factor | Raw material handling | Crushing | Weighing | Mixing | Melting | Refining | Forming | Sizing | Binding | Spinning | Oven Drying | Oven Curing | Weaving |
|--|-----------------------|----------|----------|--------|---------|----------|---------|--------|---------|----------|-------------|-------------|---------|
| Global Warming Potential (GWP) | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| Human Toxicity Potential (HTP) | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| Non-Renewable/Abiotic Resource Depletion (NRADP) | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |

| Key | Color |
|------------------|--------|
| Very High Effect | Red |
| Low Effect | Yellow |
| No Effect | Green |

Discussion

- Calculated energy values for flax agricultural processes vary due to different agricultural practices
- Lack of data available for flax fibre processing and glass fibre production
- Key environmental impact issues:
 - flax fibre - eutrophication, global warming, abiotic resource depletion
 - glass fibre - global warming, human toxicity

Conclusions

- Main environmental issues have been identified
- Now need to determine the variation between worst and best practice in each case
- Need to acquire a more comprehensive data set – clues welcome !