



minerals to metals

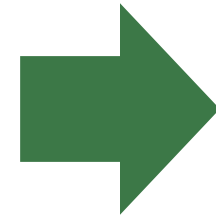
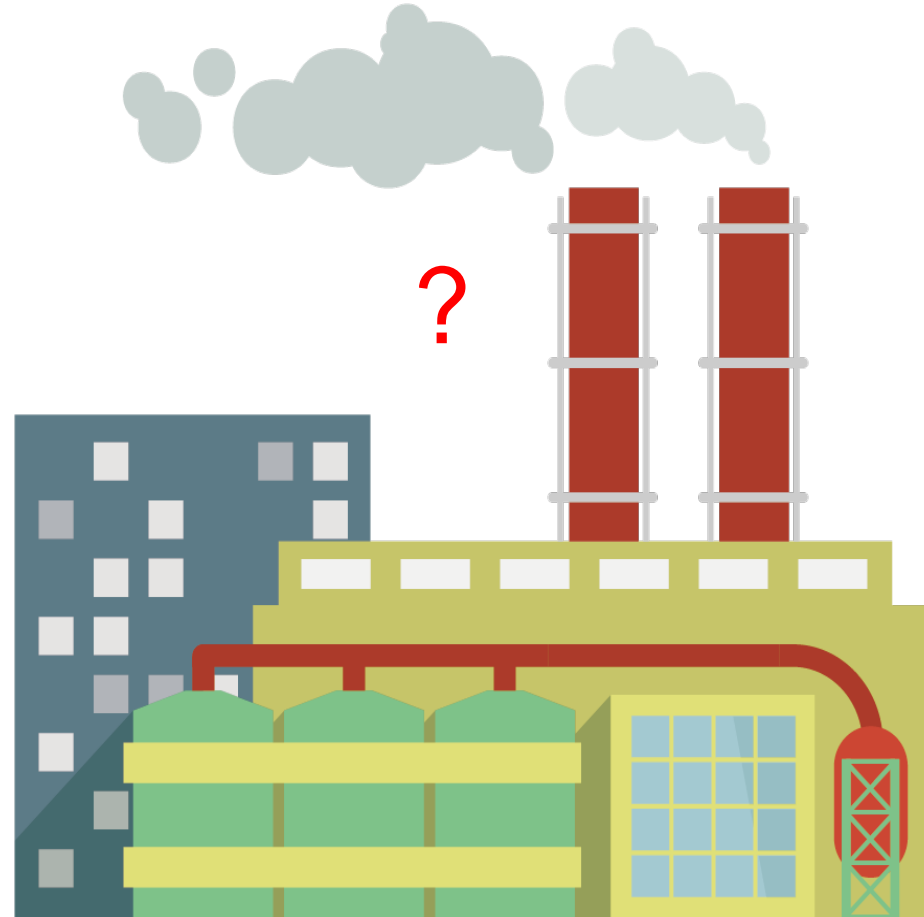
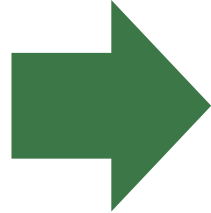
## Identification and review of the downstream options for the recovery of value from fibre-producing plants: Hemp, Kenaf, Bamboo

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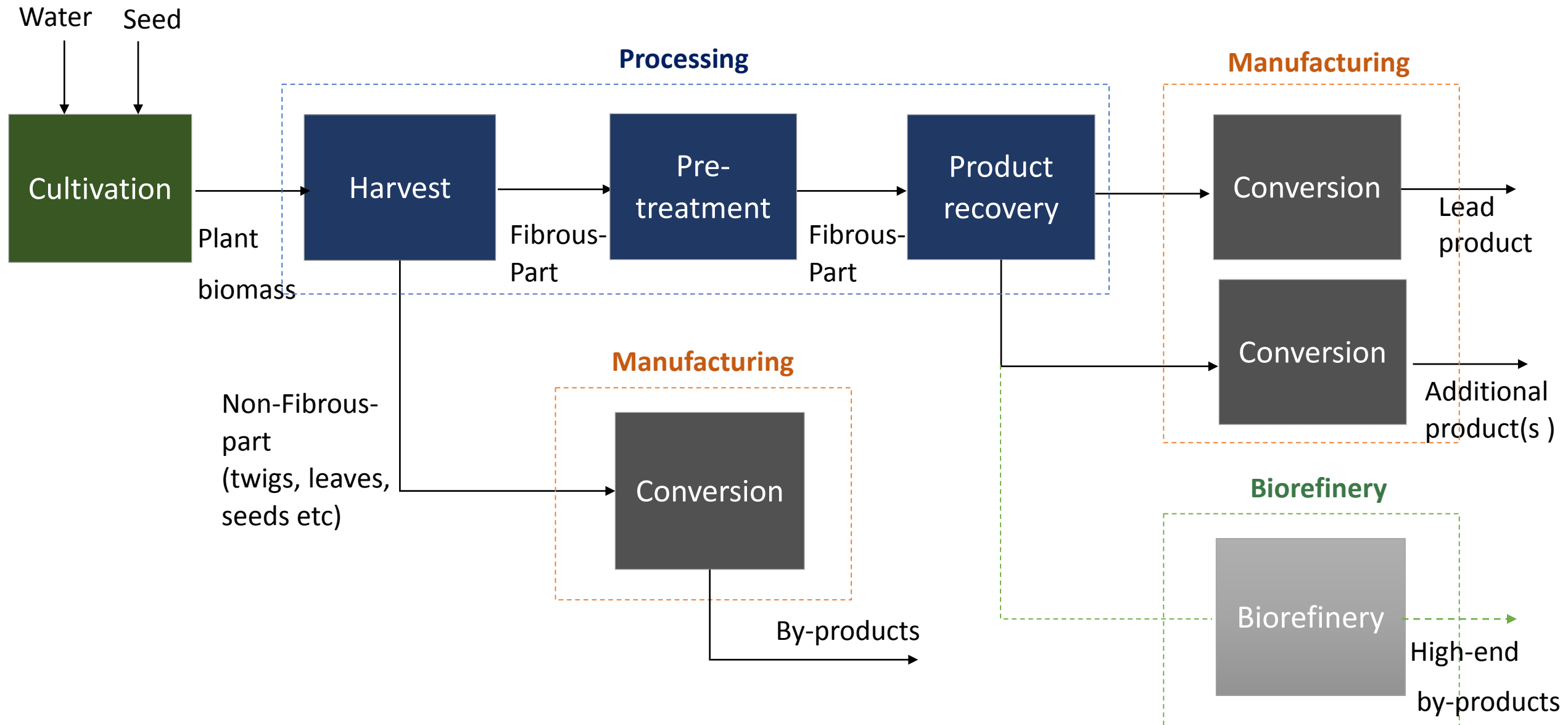
JL Broadhurst, T Chimbanga, G Hangone



# Post-mining industrial development from fibre-rich plants



# Key Processing Stages







Bast fibre plants

*Hemp*

*Kenaf*

# Bast fibre plants



Bast fibre plant



Epidermis or bark

Bast fibre

Woody core or hurd

Bast fibre plant cross section



# Bast fibre plant properties

Different bast plants have a different ratio of bast to woody core

Properties	Hemp	Kenaf
Bast fibre (% in stalk/stem)	25-30	35-40
Fibre fineness (um)	25 to 40	20 to 35
Fibre length (mm) – long fibre	16 to 40	8 to 18
Cellulose (wt%)	70 – 74	45 - 57
Hemicellulose (wt%)	18 -22	21- 23
Lignin (wt%)	4-6	8-13
Tensile Strength (MPa)	550-1000	195-700

# Bast fibre crop-to-product profile

## ENTIRE PLANT

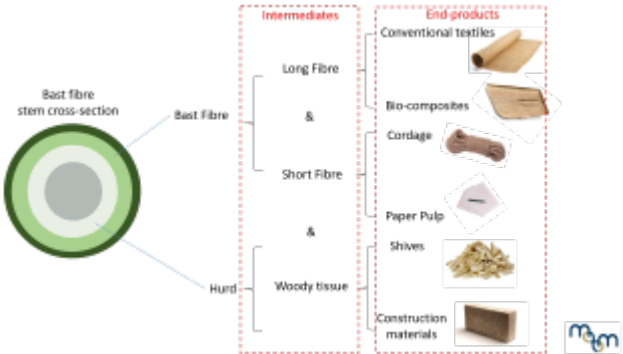
Energy



Example - Bioethanol

## STEM

Fibre + Woody tissue



Example: Hemp

## SEEDS

Seeds

or

Oil



## LEAVES

Leaves

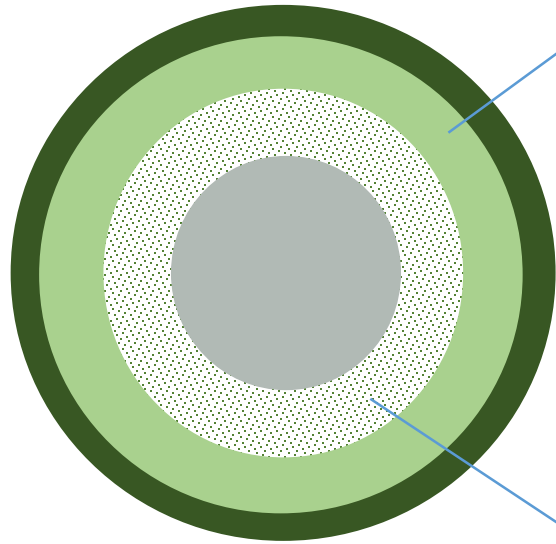
or

Medicine





Bast fibre stem cross-section



Bast Fibre  
25-40%

Hurd  
60-75%

### Intermediates

Long Fibre  
70-90%

&

Short Fibre  
10-30%

&

Woody tissue

### End-products

Conventional textiles



Bio-composites



Cordage



Paper Pulp



Shives

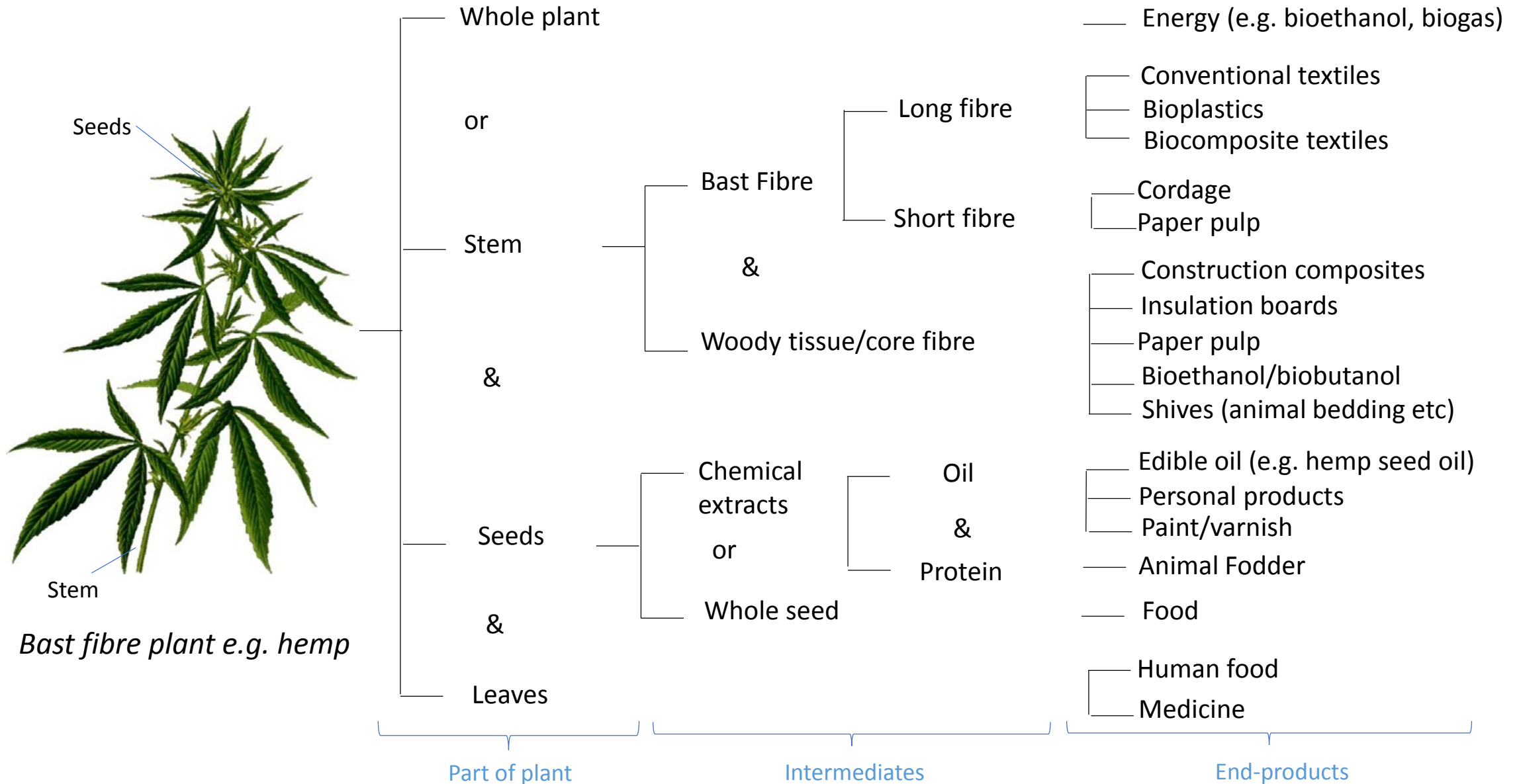


Construction materials





# Bast fibre plant multi-product profile



# Conventional textiles

- Hemp and kenaf fabrics are breathable, warm, moisture-wicking, antibacterial and biodegradable.
- Bast fibres can be easily blended with other fibres such as cotton to make lightweight softer fabrics.

Hemp fabric



Blended fabrics



# Plant Fibre re-inforced composites

- Fibre composites are made by embedding plant fibres in synthetic or biodegradable resins.
- PFRCs are being incorporated into thermoplastic matrix composites and are gaining traction in the automotive and aerospace industries.



# Construction materials

- Hemp and kenaf construction products range from insulating panels, non-woven felts for acoustic damping or levelling from woody tissue/hurds to fibre reinforced polymers for façade panels and concrete.
- The most commonly applied product in the building and construction sector is hempcrete.

Insulation matting



Fibre boards



Concrete (hempcrete)





# Paper products

- Paper pulp can be made either from short bast fibre or woody tissue.
- Paper made from kenaf bast fibre is reported to be comparable to paper from some softwoods and most hardwoods
- Paper from core fibre or woody tissue (hurd) is not as strong, but is easier to manufacture as well as softer, adsorbent and more suitable for hygienic products.



# Pharmaceuticals

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- Hemp and kenaf seeds can either be used as a whole or crushed and pressed to produce oil and a residual seed cake.
- Hemp seeds contain 30% oil by weight, whereas kenaf seeds contain 20% oil.
- Hemp flowers or leaves can be used to make cannabidiols which have low THC levels and are used for medicinal purposes.

Hemp seed oil

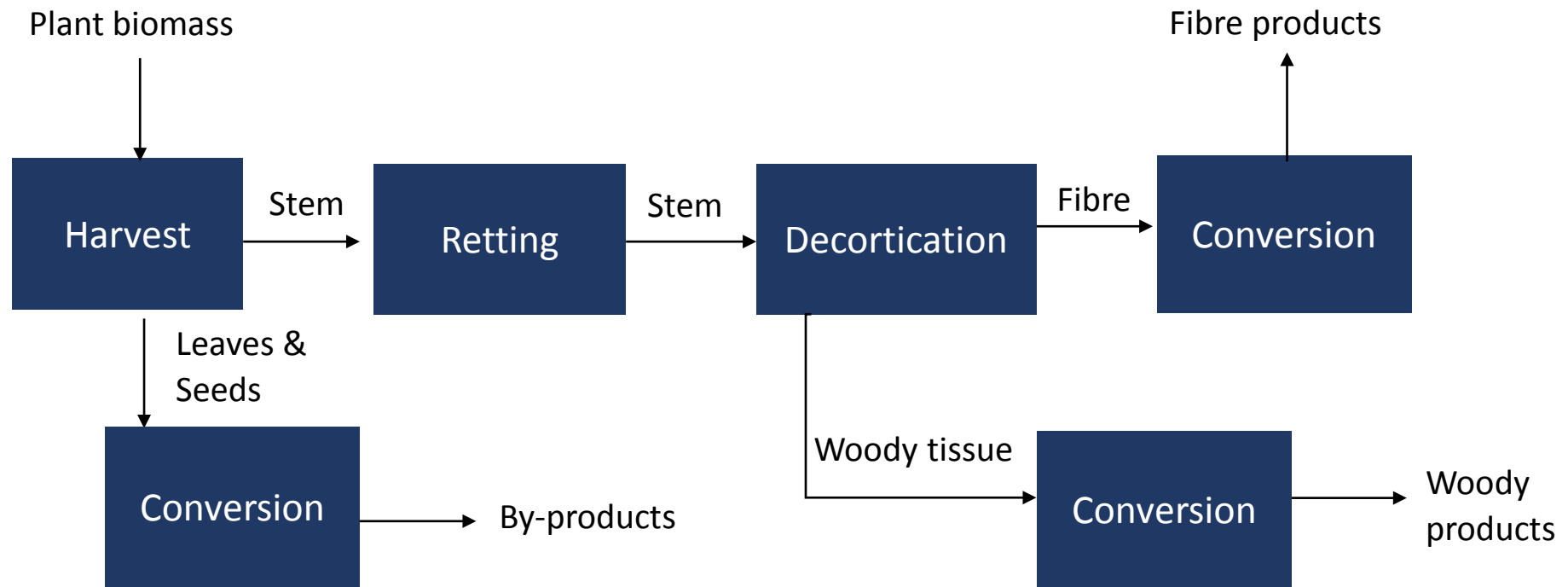


Kenaf seed oil

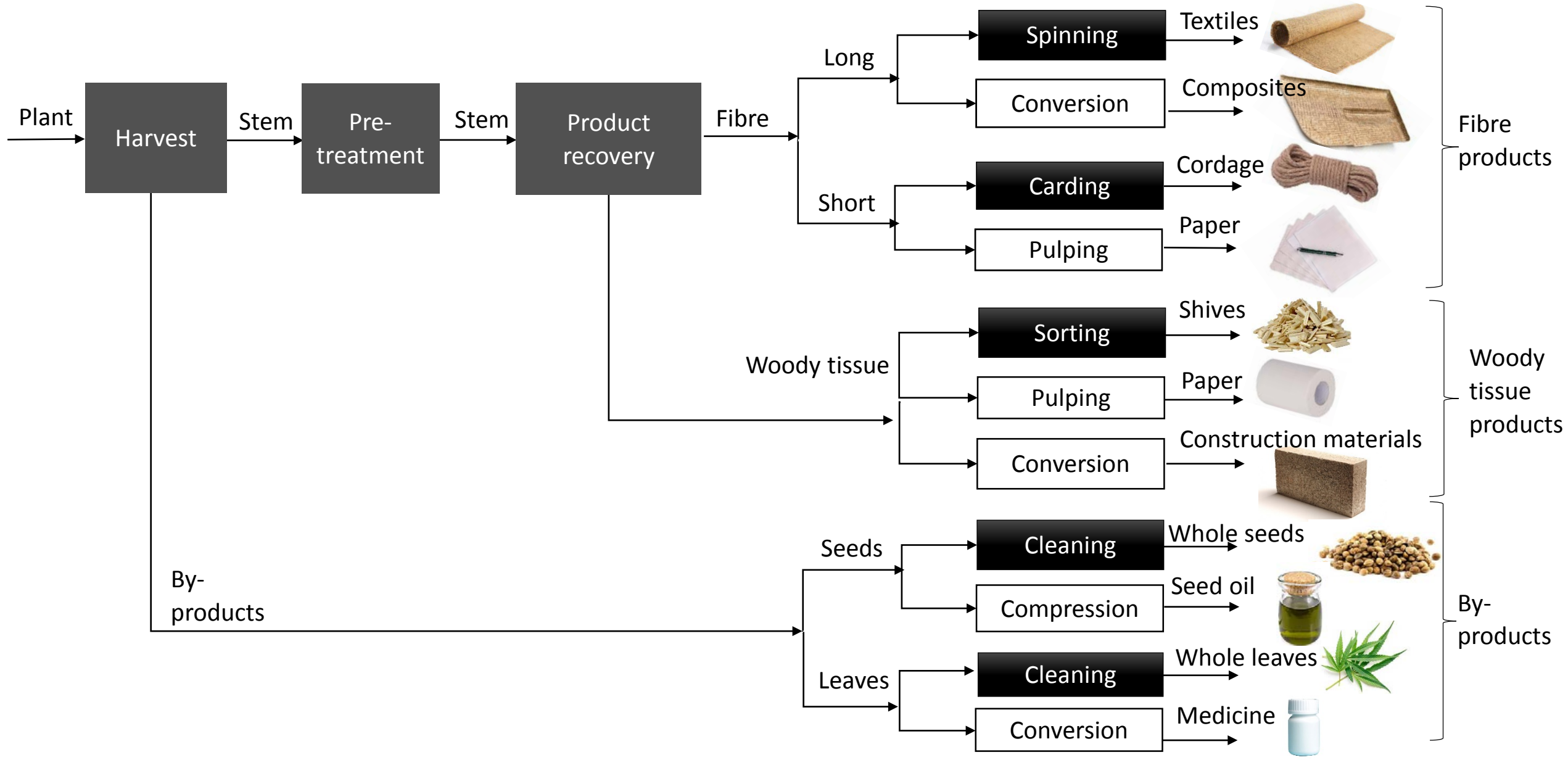


# Bast fibre processing

- Stems are pre-treated to soften them through retting or degumming, which can be chemical, mechanical or high-pressure/temperature processes.
- Bast fibre is separated from woody tissue, into long & short fibre through a process known as decortication.



# Bast fibre multi-product flowsheet options





# Environmental & socio-economic impacts

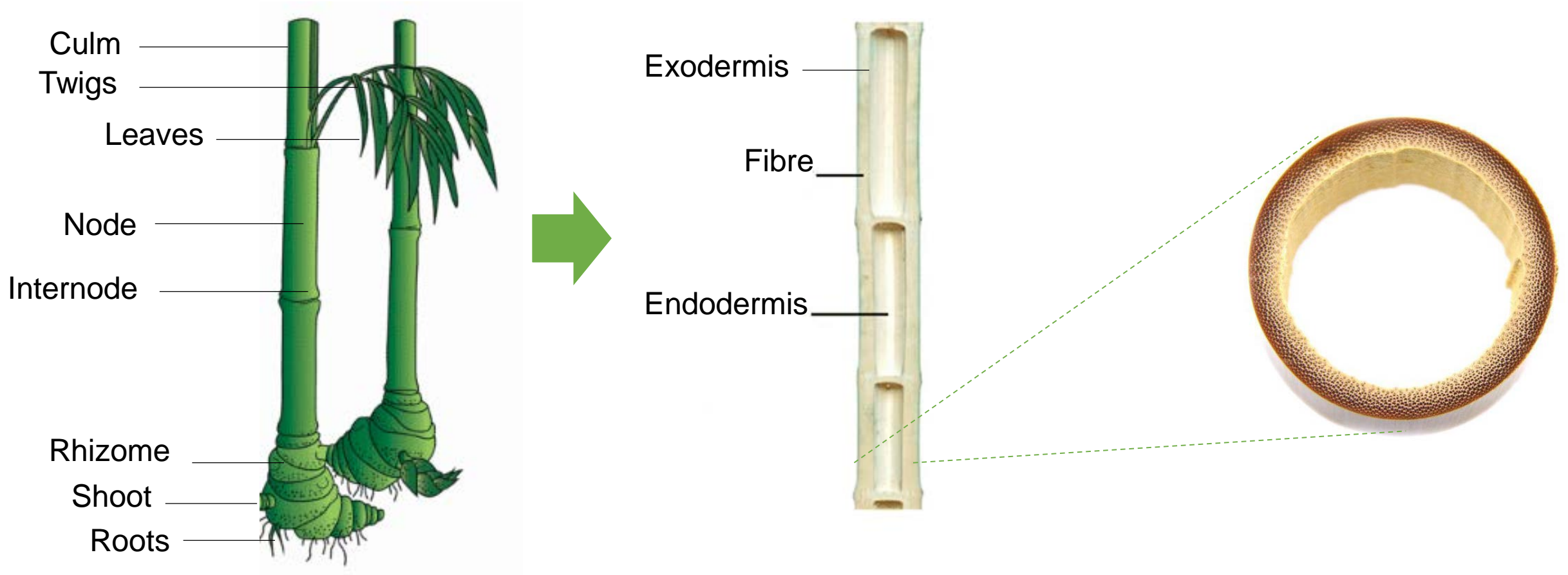
## Implications of the various product options

	Energy inputs	Water inputs	Job Creation potential	Skills level requirement
Conventional textiles	Low	Medium	High	Low
Fibre-reinforced composites	High	Low	Low	High
Construction materials	High	High	Medium	Medium
Paper	High	High	Medium	Medium



# Bamboo

# Bamboo plant structure



# Bamboo crop-to-product profile

## ENTIRE PLANT

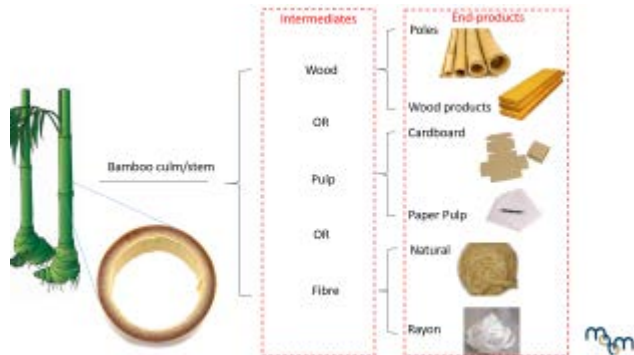
Energy



Example - Biochar

## STEM/CULM

Wood or Fibre or Pulp



## BRANCHES

Household wood products

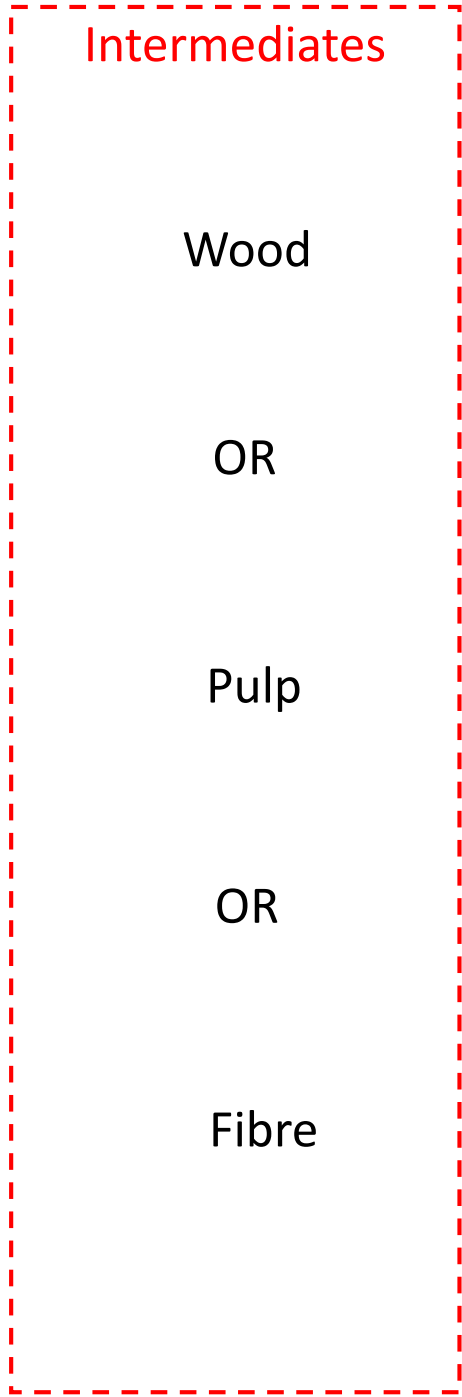
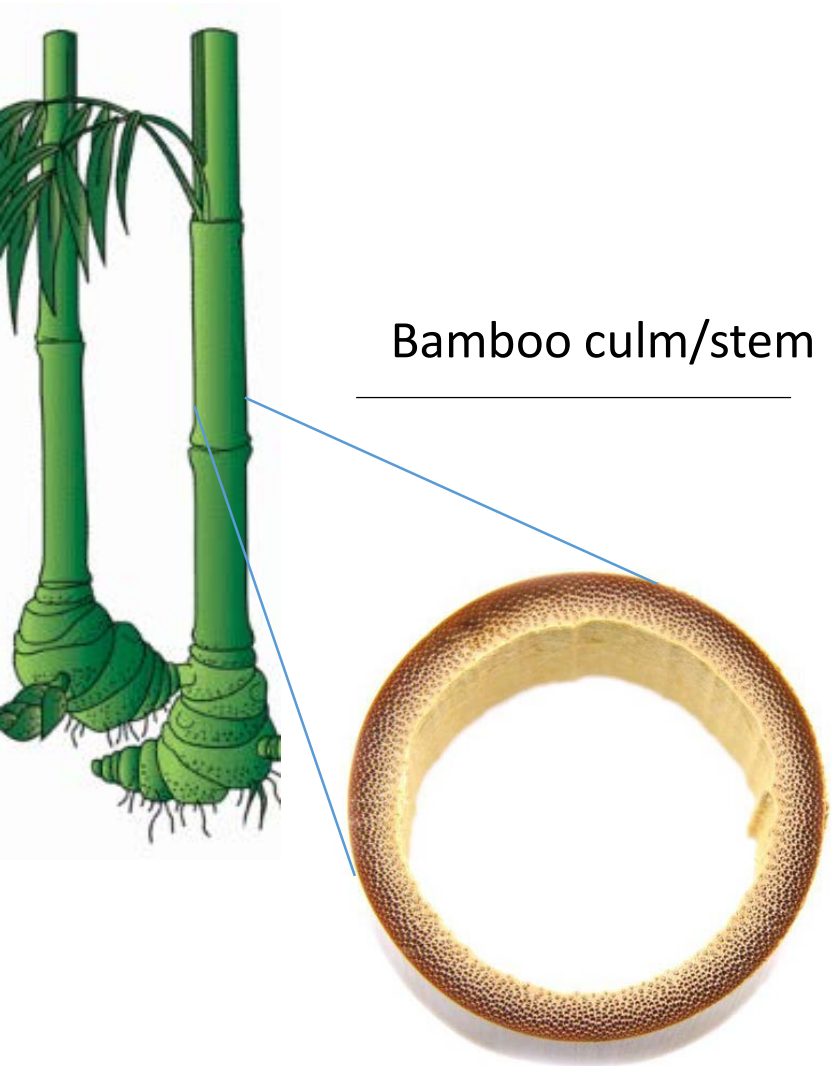


## SHOOTS

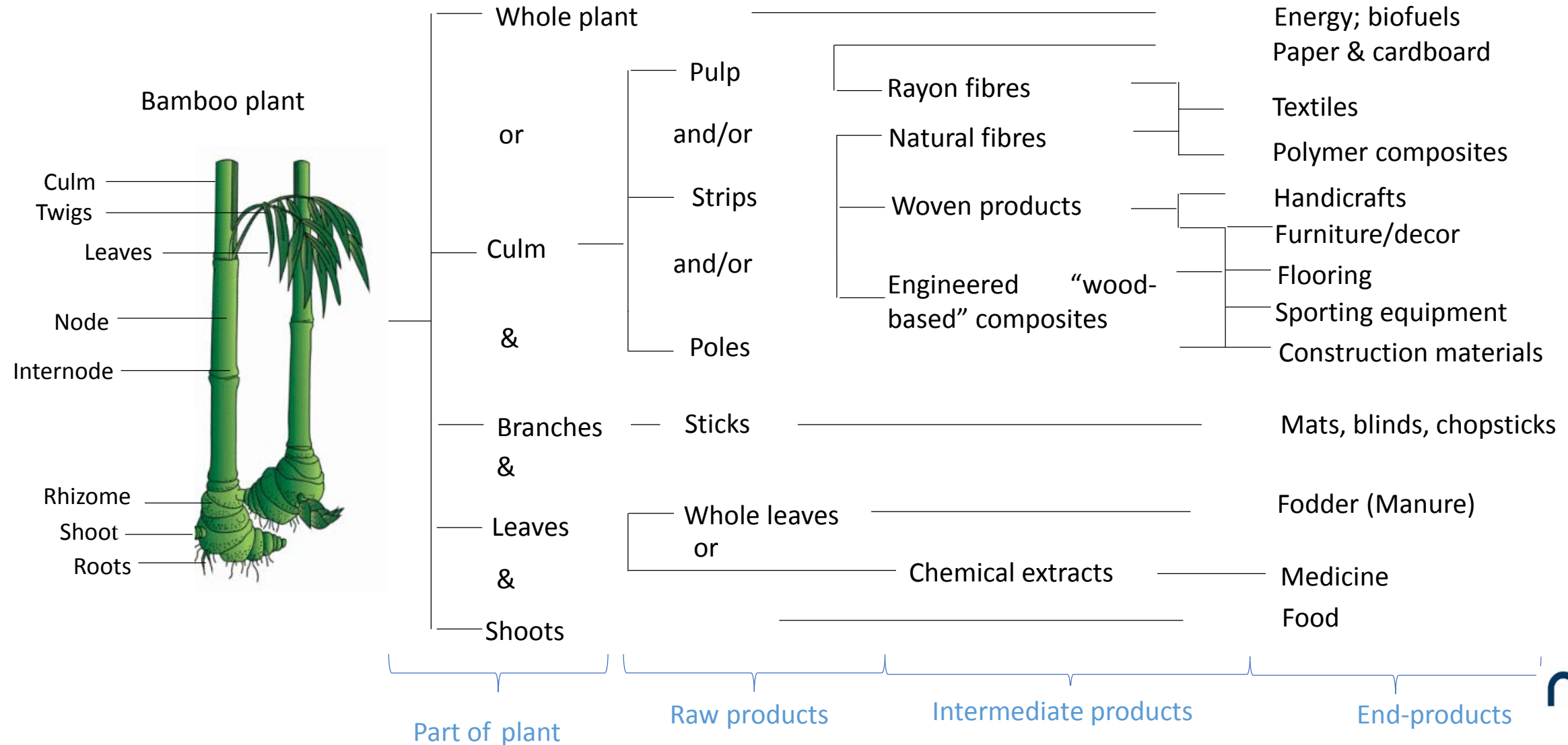
Vegetable







# Bamboo multi-product options



# Wood-based products

- Bamboo has many applications in the construction and building industries due to its woody nature and similar properties to timber.
- The culm is either used whole as poles or split into strips to make woven products or engineered bamboo wood-composites.



# Fibre-based textiles

- There are two types of bamboo textiles – bamboo linen (also called “natural bamboo fibre”) extracted by mechanical or microbial processes.
- Bamboo rayon made through chemical treatments similar to the manufacturing of rayon viscose.





# Fibre reinforced composites

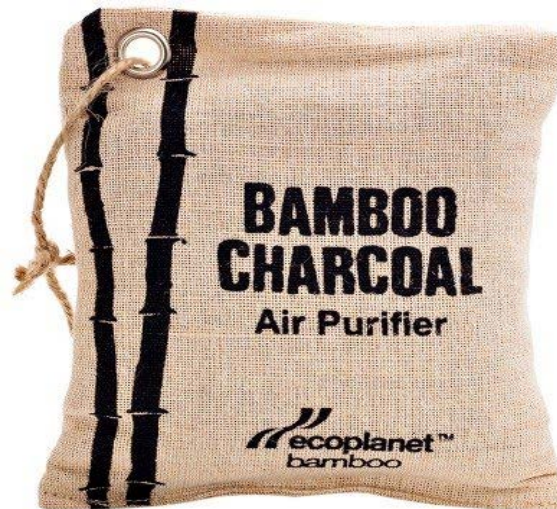
- Similar to bast fibre composites, bamboo fibres can be used to reinforce natural or synthetic polymer matrices.
- Bamboo-fibre reinforced plastic (BFRP) composites' tensile strength is comparative to mild steel and have a lower density, making them ideal for structural applications.





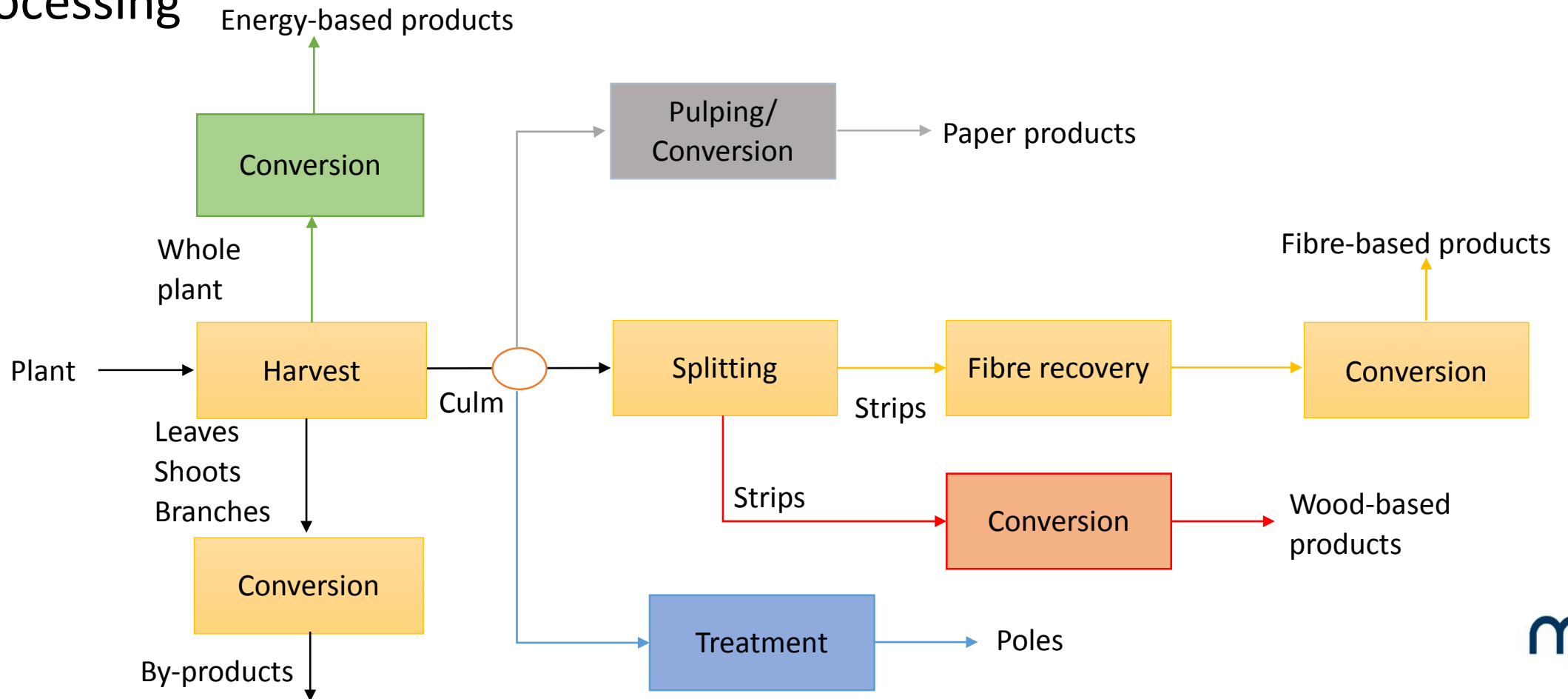
# Energy-based products

- Bamboo has a number of desirable characteristics as a fuel for combustion, such as a low ash content and alkali index compared to other bioenergy feedstocks.
- Bamboo culm can be processed into pellet form or other forms of fuels, such as biogas, bioethanol and charcoal.

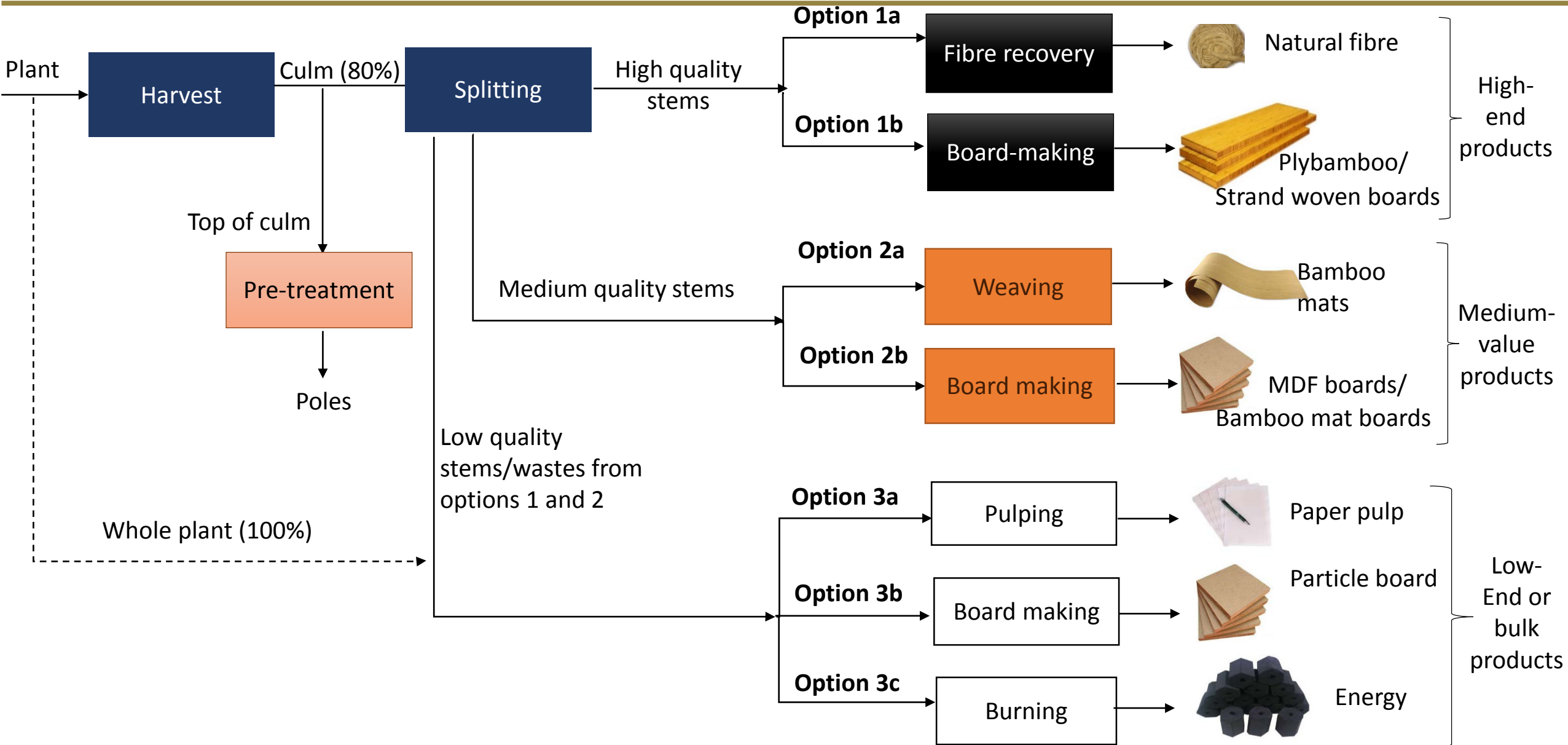


# Bamboo processing

- Each product type requires a separate treatment or processes.
- Bamboo processing is more intensive and extensive than bast fibre processing



# Bamboo multi-product processing scenarios



# Environmental & socio-economic impacts

## Implications of the various product options

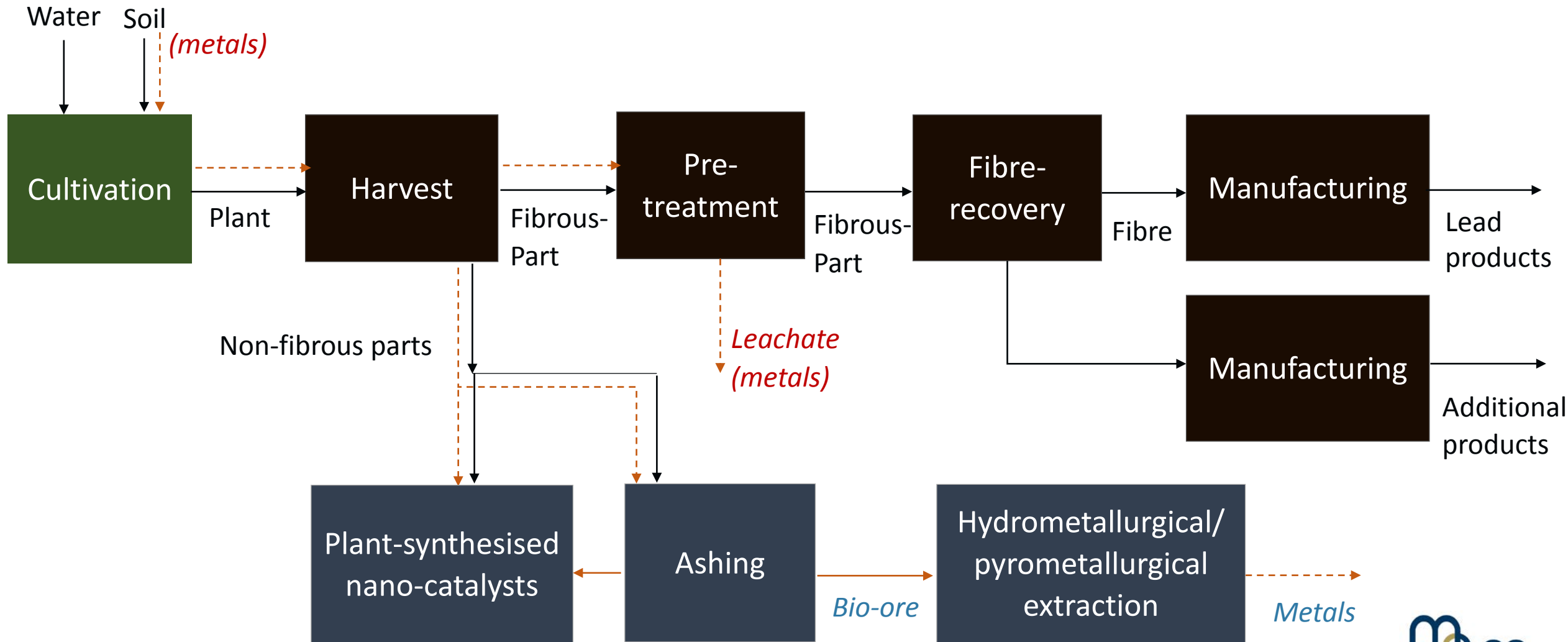
	Energy inputs	Water inputs	Job Creation potential	Skills level requirement
Wood-based products	Low	Medium	High	Low
Fibre-based textiles	High	High	Medium	High
Fibre re-inforced textiles	High	High	Medium	Medium
Energy products	Medium	Medium	High	Medium



# Potential metal recovery



# Potential integrated metal recovery process

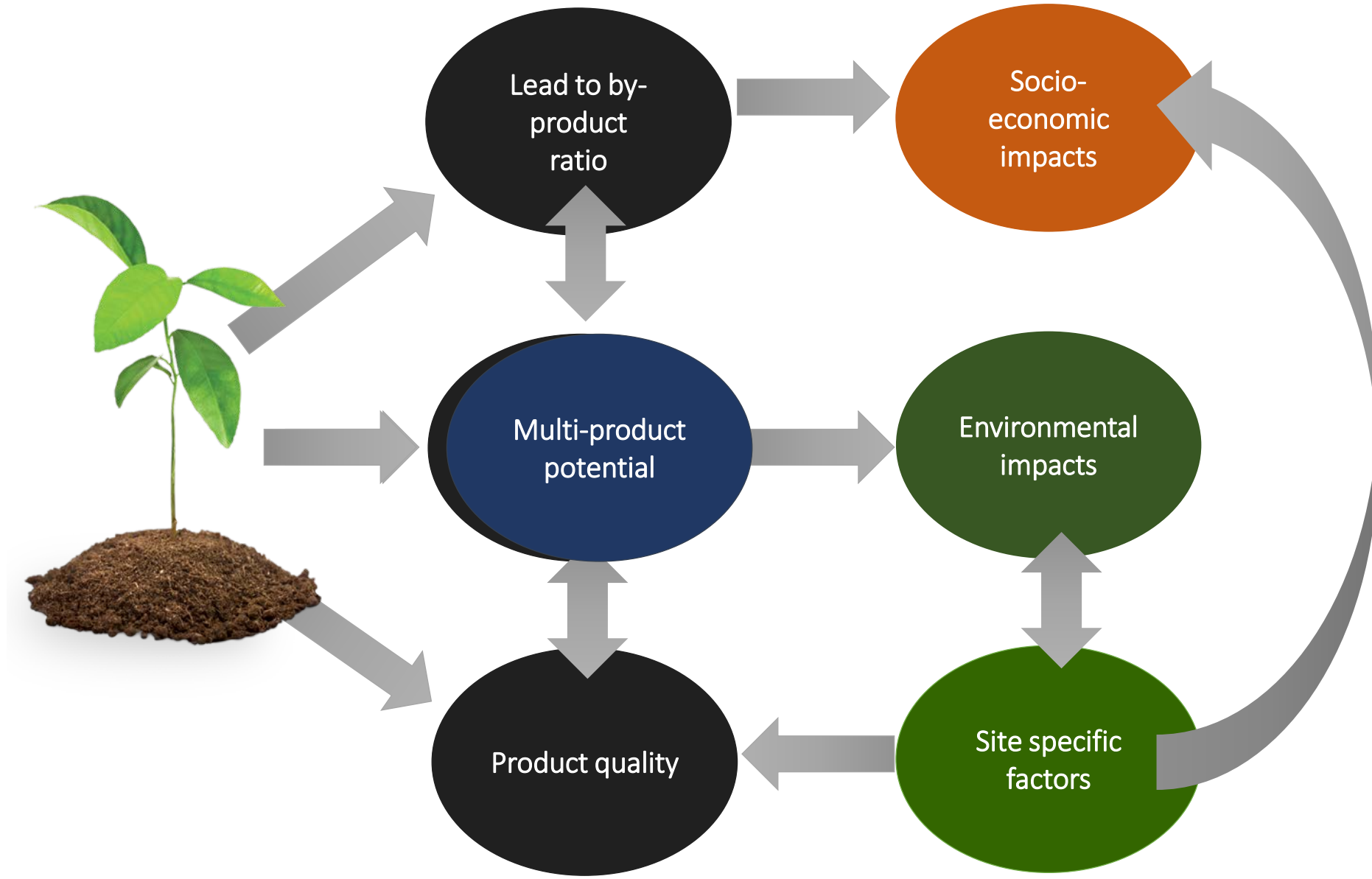


# Summary

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- All the fibre-producing plants can generate multiple products however, the range of products and targeted markets differ for the different plant types.
- There appear to be few holistic or systemic studies on the selection of products and processing of fibre-rich plants.
- This review shows that the selection of product recovery and treatment processes is highly dependent on desired product types and output of low-end vs high-end value products.

# The exploitation of fibre-based plants will depend on....



# Summary

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- Bast fibre plants appear to be the best downstream option for the production of “green” textiles and high-end niche products such as fibre-reinforced composites.
- Bamboo is more suitable as a replacement for conventional timber in the production of functional products such as wooden flooring and construction materials and paper.
- Further studies will be required to investigate the effect of contaminants on products and processing options.

# Acknowledgements



science  
& technology

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minerals to metals



MINERAL LAW  
IN AFRICA



DEVELOPMENT POLICY  
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